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Actual date of publication: May 3, 1982

EDITORIAL

The new format you see in the Virginia Journal of Science was adopted at the recommendation and request of the Publications Committee and the Council of the Academy. Though costs of putting out the Journal have been dramatically reduced through various cost-cutting measures and the help of our printer, Good Printers of Harrisonburg, it became evident that the only way to further cut costs significantly was to abandon typesetting of text and go to photoreproduction of camera-ready typed copy. It is the editor's hope that this budget-enforced change will not decrease the quantity or quality of manuscripts that are submitted to the Journal.

The editor wishes to apologize to all who have submitted manuscripts in the last year and to the membership for the failure of both the reviewing process and the Journal to keep on schedule for the last nine months. He was shut out of his office for 6 months during the removal of flaking asbestos insulation from the Life Sciences Building at William and Mary, and is only now beginning to catch up on the backlog of editorial work that accumulated. He hopes the rest of the issues for 1982 will be on time.

Virginia Journal of Science
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Spring 1982

The Seasonal Distribution of Aerobic, Heterotrophic Bacteria in an Urban Chesapeake Bay Estuary

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ABSTRACT

The Chesapeake Bay has the largest and most important commercial estuaries on the east coast of the United States. Ironically, there is a paucity of bacteriological data available for the Hampton Roads area. This study of Lynnhaven estuary bridges our knowledge gap about bacteria native to one of Virginia's shellfish-growing areas. The occurrence and distribution of the total viable count of aerobic, heterotrophic bacteria not only is influenced by variations in the local environmental characteristics of Lynnhaven but also by an apparent seasonal change in the ecosystem microflora. In general, pelagic and benthic densities increased from Lynnhaven's inlet to the Eastern and Western headwater branches. This spatial distribution is an apparent response of native bacterial populations to dilution, nutrients and physical factors in the environment.

INTRODUCTION

The Lynnhaven Estuary is an important commercial shellfishing and recreational region of the lower Chesapeake Bay. Similar to the Bay, little information has been collected about the bacteria, their distribution, or their activities in this estuary. These microorganisms provide an intricate link in the complex food chain existing in estuarine environments. Even less is known of nonpoint pollutant effects on these bacteria.

Relatively few studies have been reported in the literature on Bay microorganisms. Numerous studies were done in the upper reaches in Maryland waters (Oliver and Colwell, 1974; Walker and Colwell, 1974; Cook and Goldman, 1976; Kaper et al., 1978, to mention a few) but no bacteriological studies in the Hampton Roads area have been published. This first phase of bacterial studies in the Lynnhaven Estuary was initiated to understand the distribution of bacteria in this important lower Chesapeake Bay urban estuary.

MATERIALS AND METHODS

Environmental Setting: The Lynnhaven Estuary is a well mixed, temperate lower Chesapeake Bay estuary (37° 53'N, 76° 05'W). This estuary is located in Virginia Beach and has been recognized through the years as an important recreational and commercial shellfishing area. Unlike many of the estuaries along the east coast of the United States, the Lynnhaven has become a developing urban estuary in which the predominant land use is either single and multifamily housing or agricultural. Only 30% of the land is classified as vacant and undeveloped (data provided by the City of Virginia Beach, Department of Planning, 1976). The Lynnhaven Estuary is separated into the

Eastern and Western branches and has a variety of marsh vegetation including Spartina, Juncus, Phragmites, Baccharis and Iva.

Eleven sampling sites were distributed throughout the estuary from the inlet to the headwater of both the Eastern and Western branches of the Lynnhaven (Figure 1). These stations were situated to provide good spatial distribution throughout the estuary and to represent typical sediment types. All sediment sampling sites were located subtidally in waters with a mean depth of 1.55 m but ranging from 0.51 to 2.28 m throughout the entire system during the sampling period.

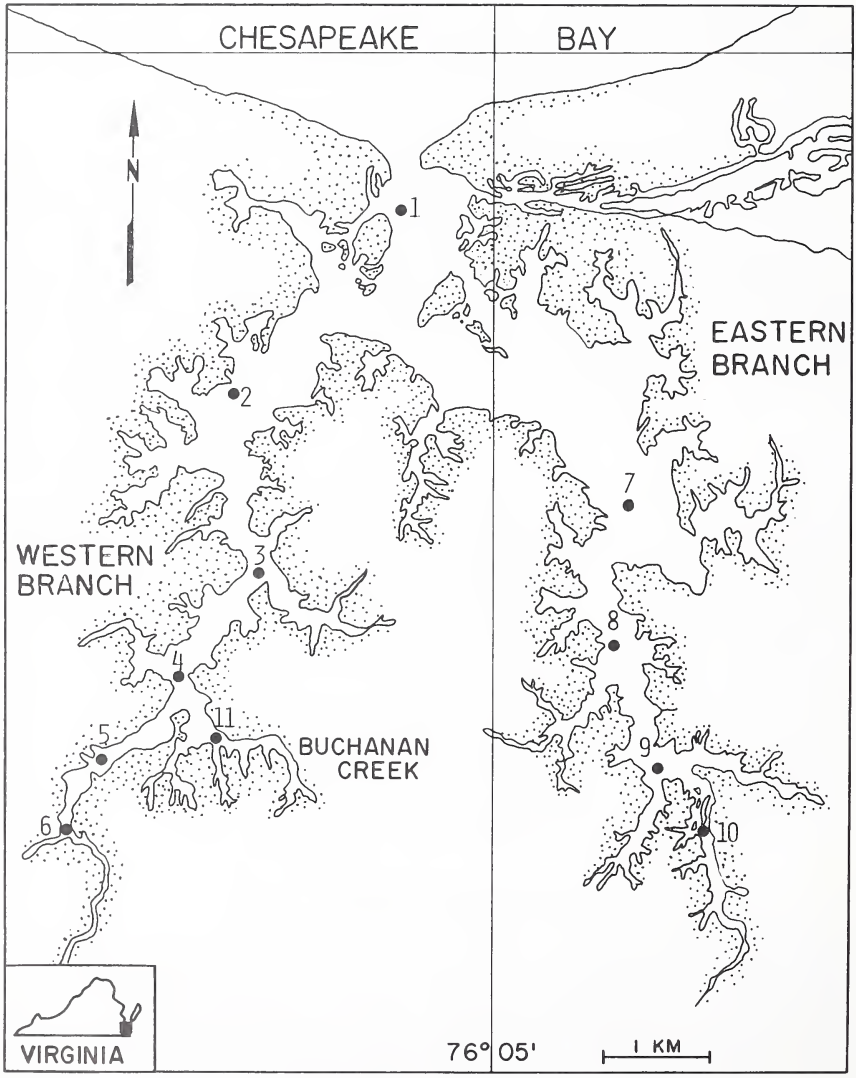

Figure 1. A map of the Lynnhaven estuary showing the locations of the 11 sampling sites.

Samples were collected for quantitative assay in triplicate from each station at least bimonthly. Grab samples of subsurface water were collected in sterile glass widemouth bottles prior to sediment sampling and immediately placed on ice. Sediment samples were collected with a hand-held coring device. Each primary core was immediately subsampled twice with a modified 10-cc syringe to obtain 3-cc subcores. One subcore was transferred to a sterile precalibrated bottle for bacteriological analysis, and the other was placed in a clean, preweighed aluminum pan for dry weight analysis. Total elapsed time from the beginning of sampling to initiation of analyses in the laboratory did not exceed six hours. All samples were collected during the day at or near high tide because of the limited accessibility of the stations on the headwaters of the Lynnhaven branches.

Total viable counts (TVC) of aerobic, heterotrophic bacteria were determined by a serial dilution-spread plate technique. Visible colonies were counted after seven days of incubation at room temperature on spread plates containing a sea-water yeast extract medium (SWYE) (Quigley and Colwell, 1968). Sediment TVC were enumerated by the same methodology employed for water samples except in the preparation and dilution scheme. The 3-cc subcore collected for bacteriological analysis was diluted to 100 ml with sterile phosphate buffer (0.02 M, pH 7.75) and blended at high speed for 2 minutes. Aliquots of the diluted sample were serially diluted and spread on SWYE. The results were reported as TVC/g dry weight of sediment.

Suspended material was gravimetrically determined by filtering 100-400 ml of sample through preignited and tared glass-fiber filters (Millipore Corp., 1973).

Water temperature and salinity were recorded *in situ* using a Beckman portable salinometer (Model RS5-3); sediment temperature was measured with a mercury thermometer. Dissolved oxygen (DO) was measured *in situ* using a Yellow Springs Instrument oxygen meter (Model 54) calibrated in the field by the water-saturated air technique. Field measurements of DO were corrected for salinity and reported as ppm and percent saturation. Water pH was measured in the lab with a Corning pH meter (Model 7) and values were corrected for *in situ* water temperature (Strickland and Parsons, 1972).

Water depth (m) was directly measured with a calibrated, weighted nylon rope. Precipitation data were obtained from the meterological section of Oceana Naval Air Station, Virginia Beach.

Sediment dry weight was obtained by drying replicate sediment subcores at 100°C for 3 days, cooling, and reweighing the core. Statistical analyses were accomplished with a Dec-System 10 computer system and programs available in the SPSS (Nie et al, 1975) statistical packages.

RESULTS

The horizontal distribution of pelagic and benthic heterotrophic bacteria was evaluated from the 11 estuarine sampling sites. In general, densities of these bacteria decreased from the headwaters to the mouth (see Figures 2-4). Occasionally, this gradient was disrupted by sharp declines in sediment counts (November - Station 6 (Figure 2a); July and August - Station 5 and 6 in the Western branch (see Figures 3b and 3c, respectively). Benthic bacterial populations in the extreme headwaters of the Eastern branch were frequently lower than at Station 9 to the north. An exceptionally low density with considerable variability was recorded at Station 10 during July (Figure 3b). Pelagic bacteria, on the other hand, did not fluctuate with such sharp declines as did

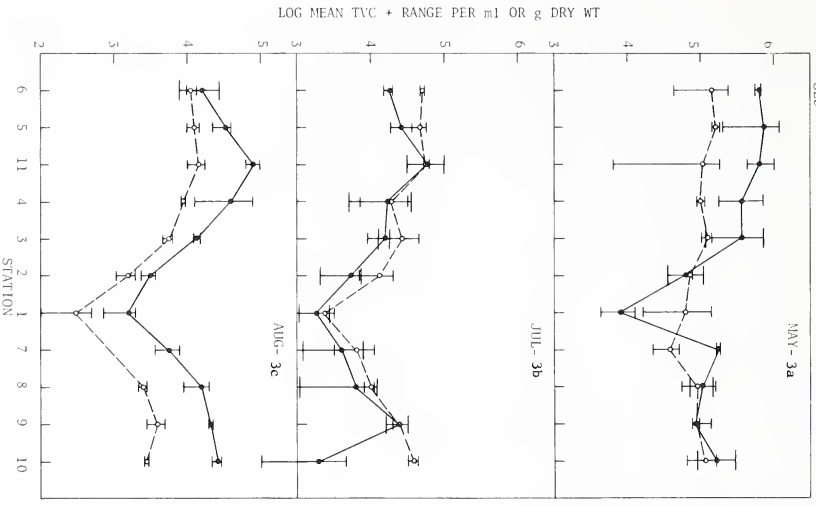

Figure 2. Results of aerobic, heterotrophic bacteria (TVC) from pelagic and benthic samples for the months of November, January and March.

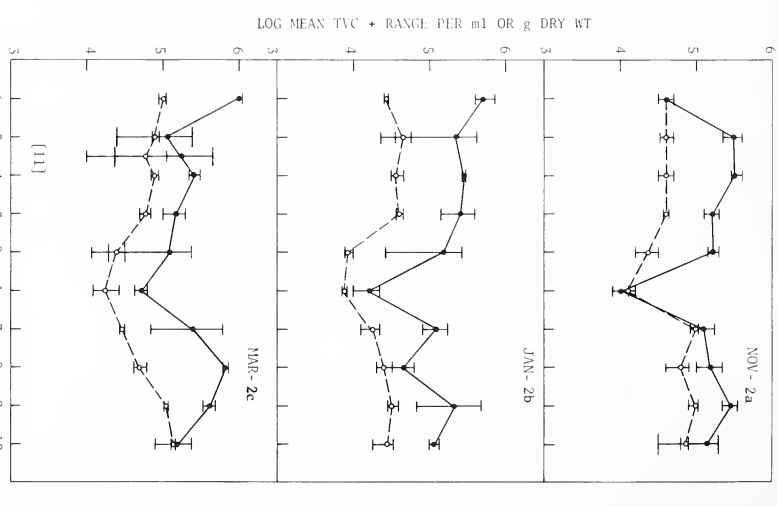

Figure 3. Results of aerobic, heterotrophic bacteria (TVC) from pelagic and benthic samples for the months of May, July and August.

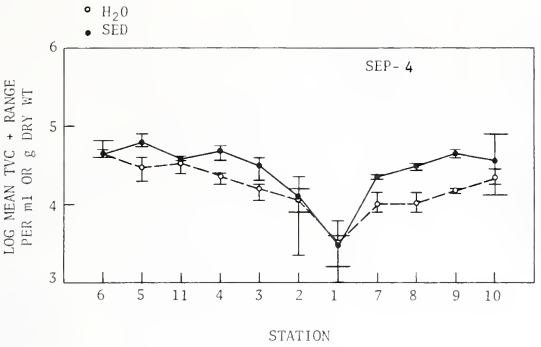

Figure 4. Results of aerobic, heterotrophic bacteria (TVC) from pelagic and benthic samples for the month of September.

the benthic samples during the yearlong study. Average bacterial densities (±1 standard error) from 214 observations were 56,572 ± 11518/ml and 152,451 ± 14,873/g dry weight for pelagic and benthic bacteria, respectively.

Composite data analysis from 21 observations per station showed a distinct pattern throughout the Lynnhaven. This gradient pattern was measureable in both pelagic and benthic communities. The general trend showed a decrease in bacteria from the headwaters to Lynnhaven inlet (see Figures 5 and 6). The range of values from headwaters Stations 6 and 10 (log = 4.79 and 4.78, respectively) to Lynnhaven Inlet (log = 4.17) was not great (Figure 5). Similar trends in sediment also were recorded but with a greater reduction in density at the inlet (Figure 6). Sporadic peaks were occasionally recorded in water samples (Station 4, log = 5.21 and Station 11, log = 4.90), while troughs were observed in the sediment samples at Station 10 (10g = 4.94).

In order to assess the relative seasonal trends in the bacterial populations, samples were collected bimonthly during the one-year period. Pelagic TVC were lowest in January and August but peaked in May and September (see Figure 7). Benthic densities, on the other hand, were highest in March and May and lowest during the summer months of July, August, and September.

No significant linear relationships were calculated between TVC and any of the physical-chemical parameters measured for either the aquatic or benthic environments except for a very weak response between benthic TVC and total suspended solids (r = 0.26, significant at the 0.01 level). The physical-chemical data collected during the study are presented elsewhere (Erkenbrecher, 1981).

DISCUSSION

The Lynnhaven Estuary is an important recreational and commercial shellfishing area in the lower Chesapeake Bay. However, the quality of this estuarine environment is impacted by its urban setting and as a result has suffered from the sporadic opening and closing of its shellfishing areas for many years. Although routine ambient water quality studies have been completed in this system, no attempts have been made to document the distribution of aerobic, heterotropic bacteria or the impact of the major nonpoint pollutants on their occurrence and activities.

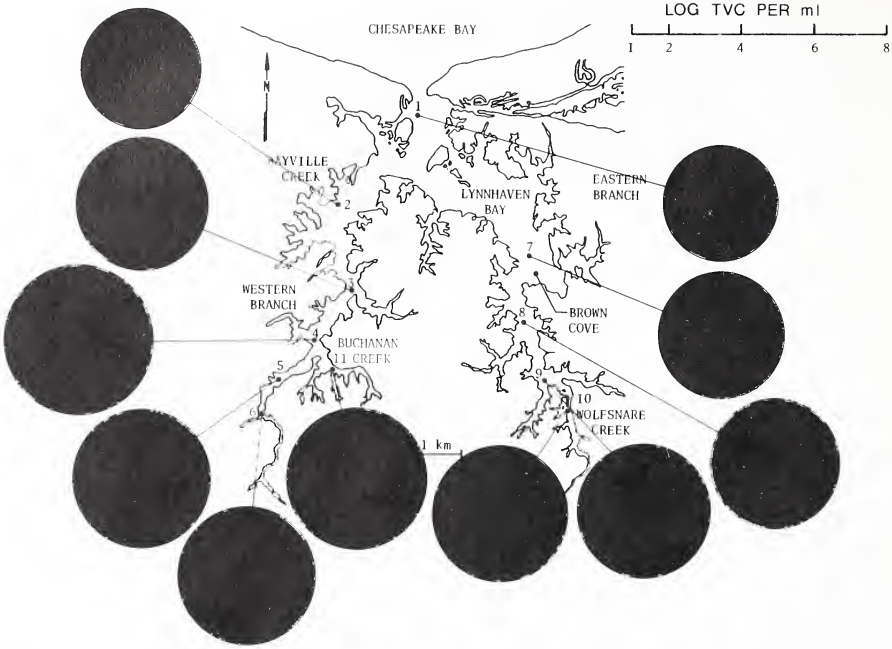

Figure 5. A map illustrating the spatial distribution of pelagic aerobic, heterotrophic bacteria (TVC) throughout the Lynnhaven estuary for each of the 11 sampling sites.

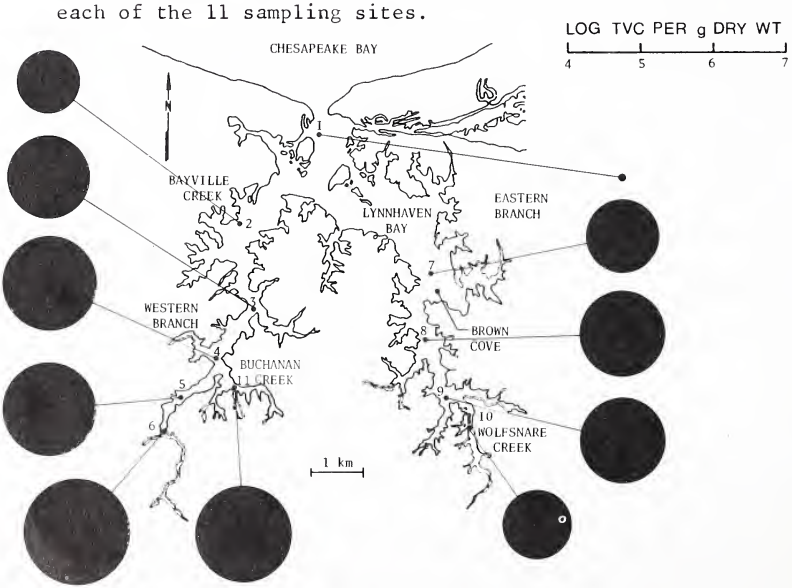

Figure 6. A map illustrating the spatial distribution of benthic aerobic, heterotrophic bacteria (TVC) throughout the Lynnhaven estuary for each of the 11 sampling sites.

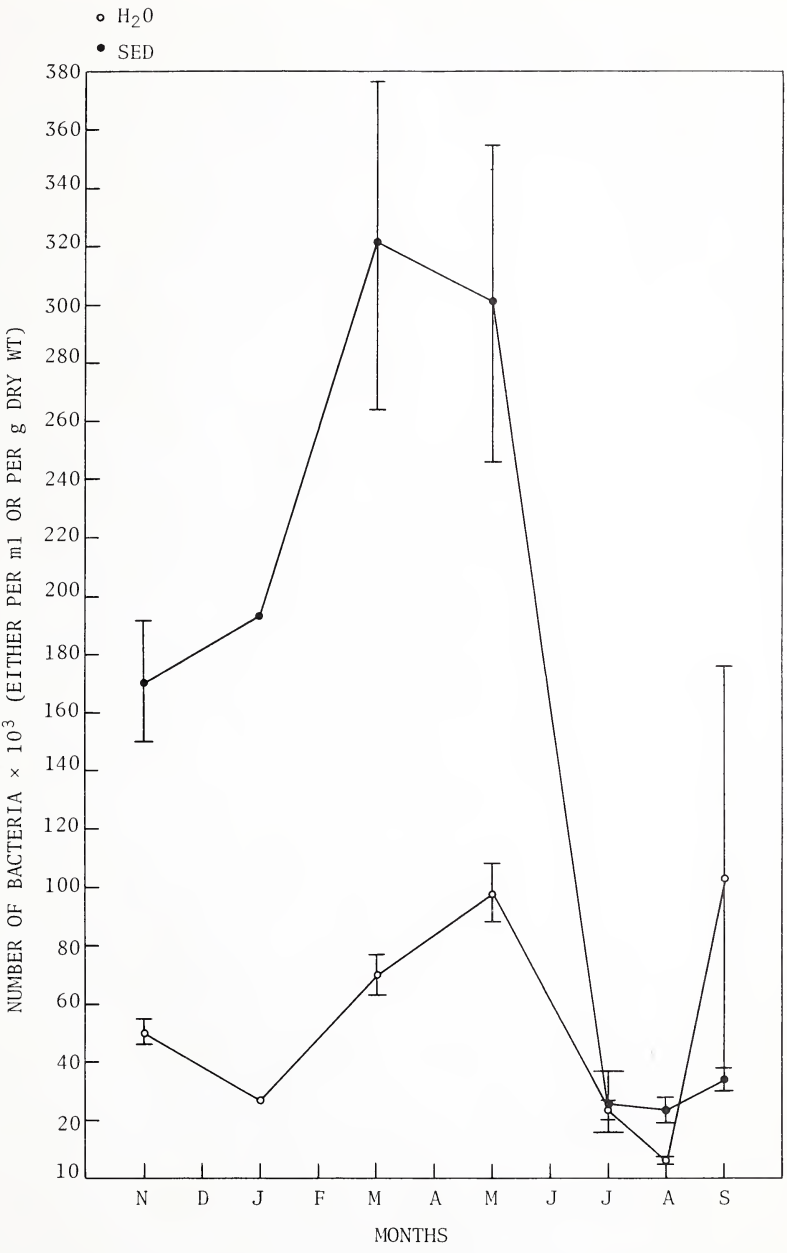

Figure 7. Temporal distribution in the aerobic, heterotrophic bacterial populations during the yearlong study of the Lynnhaven estuary. Mean ± Standard Error for n = 30 per month.

Overall, mean TVC in Lynnhaven's shellfishing waters are comparable to the results of Cook and Goldman (1976) and Morgan et al. (1976) for the upper Chesapeake Bay region but are almost four times higher than densities found by Erkenbrecher (1976) for an unpolluted coastal estuary in South Carolina. This may reflect either enumeration technique differences or a combinination of physical, chemical and biological differences that characterize the two systems. In support of the latter, Austin et al. (1979) reported that even under similar environmental conditions, the bacterial taxa are quite different and subject to geographical differences between estuarine systems.

Observations of decreasing bacterial densities toward the more saline inlet station are similar to studies documenting the decrease of coliforms in salt water environments (Ogawa, 1974; Van Duck, Van De Voorde, and Reybrouch, 1973; Orlob, 1956; Ketchum et al., 1952, to mention a few). However, reduced densities near the inlet probably reflect more of a dilution from flooding tidal waters than from the bacteriocidal properties of sea water. On the other hand, the sharp reduction in benthic TVC at the inlet station is due to coarser grained sediments with less surface area and organic content, as well as, the influence of the high velocity tidal currents at this site which causes continuous disturbance and loss of bacteria from abrasion of the sediment particles. The spatial distribution results in this study were consistent with the hypothesis of Millwood (1971) and Erkenbrecher (1976) that the more inland the sampling site, the higher the bacterial count.

Several studies reported the seasonal cycle of aerobic, heterotrophic bacteria in coastal waters but there appears to be no one dominant factor responsible for observed fluctuations in annual abundance. Thus, aerobic, heterotrophs have been associated with changes in water temperature (Wood, 1965; Sieburth, 1967), phytoplankton populations (ZoBell, 1946; Rheinheimer, 1971), turbidity (Rheinheimer, 1971; Day et al., 1973) and organic nutrient load (Hood, 1973 as cited in Day et al., 1973). Peaks in pelagic bacterial numbers in the Lynnhaven during May and September may be correlated with phytoplankton development as suggested by Rheinheimer (1977). That is, the spring peak followed the spring phytoplankton bloom, and the fall peak followed the late summer bloom typical of temperate estuaries (Riley, 1967). Phytoplankton death after each bloom causes an abundant nutrient release that provides the stimulus (as nutrients) for bacterial proliferation. In a similar vein, the summer decrease in aerobic heterotrophs may be due to less favorable nutrient conditions and accelerated zooplankton grazing activities (Rheinheimer, 1977)). Seasonal variations in benthic bacteria were more pronunced in spring. Maximum peaks occurred in March and May, but the typical fall peak did not materialize. Because benthic bacteria often originate as bacteria attached to floating debris prior to settling, the absence of a fall peak may mean that extremely low pelagic TVC during July and August affected sediment replenishment. Lower pelagic counts may be due to lack of rainfall between the months of May and September in contrast to rainfall occurring in January (5.3 cm) and March (3.8 cm). This variation also could explain the early spring peak. A significant correlation ($r = 0.26$, at the 0.01 level) was calculated between benthic TVC and total suspended solids.

ACKNOWLEDGEMENTS

Appreciation is given to Virginia Water Resources Resources Research Center for supporting this study under Grant A-080-VA. Special thanks is given to Deardra Dew for typing this manuscript and for student assistance in the Marine Microbial Ecology and Pollution Lab at Old Dominion University.

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Immunodepression During *Trypanosoma Gambiense* Infections in Rabbits

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ABSTRACT

Experimental data show that in rabbits chronic infections with Trypanosoma gambiense, the etiologic agent of African Sleeping Sickness, result in depressed immune responses to soluble antigen, bovine serum albumin, and particulate antigen, human type B+ erythrocytes. Both primary and secondary humoral responses to antigens are significantly impaired during infection. Evidence is presented suggesting IgM immunoglobulin synthesis is impaired to a greater degree than IgG immunoglobulin synthesis. The mechanisms and epidemiologic implications of trypanosome-induced immunosuppression are discussed.

INTRODUCTION

It is now well established that many parasitic infections result in depression of the immunologic responsiveness of the infected host (for reviews see Parasites in the immunized host: mechanisms of survival, 25th Ciba Foundation Symposium, 1974 and Ogilvie and Wilson, 1976). Protozoan diseases, including malaria, African and American trypanosomiasis, toxoplasmosis and leishmaniasis, have all been shown to render the infected host immunocompromised and susceptible to bacterial (Kaye et al., 1965), viral (Wedderburn, 1974) and other parasitic infections (Philips et al., 1974). Furthermore, there is a good evidence to implicate holoendemic protozoan diseases as a predisposition toward neoplasia (Burkitt, 1969 and Ackerman and Seed, 1976a).

In 1973 Greenwood and associates reported that human patients suffering from Trypanosoma gambiense infections (i.e., African Sleeping Sickness) exhibited depressed immune responses to Salmonella, tuberculin and Candida antigens. Similar effects have been reported in experimental trypanosomiasis of rodents (Goodwin et al., 1972; Urquhart et al., 1973; Ackerman and Seed, 1976b). The present investigation was conducted to examine the effects of T. gambiense infections on the immunologic capacities of rabbits. As in humans, chronic trypanosome infections in rabbits are characterized by low levels of parasitemia, numerous waves of peripheral parasitemia each possessing distinct surface antigens, hypergammaglobulinemia and high titers of antibody to the antigens of the relapsing strains (Seed et al., 1969 and Desowitz, 1970).

MATERIALS AND METHODS

The Wellcome TS strain of T. gambiense was used throughout this study. It has been continuously passaged in rodents since its isolation from a human patient in 1921. The strain was maintained by passage every second day through 25 g white mice. Blood trypanosomes were harvested from mice as described by Seed and Baquero (1965) and suspended in glucose-Ringer's phosphate buffer (Seed and Gam, 1966). New Zealand albino rabbits were infected by a single intraperitoneal inoculation of 1×10^6 organisms suspended in glucose-Ringer's phosphate buffer. Rabbits were bled (approximately 10 ml) prior to infection, prior to antigen exposure and at intervals after immunization. All sera were heated at 56^oC for 30 min. and stored at -20^oC until used.

Rabbits were immunized with either human erythrocytes (particulate antigen) or bovine serum albumin (soluble antigen). Fresh human type B+ erythrocytes (RBC) were washed three times in 0.1 M phosphate buffered saline, pH 7.2 (PBS) immediately prior to injection. One non-infected and 1 infected rabbit were injected intraveneously with 3.5×10^6 RBC, bled after 10 days, reimmunized the next day (same dose and route) and bled again 10 days after reimmunization. One non-infected and 2 infected rabbits were injected intraveneously with 3.5×10^6 RBC, bled after 10 days, reimmunized the following day with the same antigen dose via an intraperitoneal route and bled again 10 days after reimmunization. Bovine serum albumin (BSA, Sigma Chemical Co.) was diluted to 5 mg/ml in PBS and centrifuged at 15,000 g for 60 min. immediately prior to injection. One non-infected and 1 infected rabbit were injected intramuscularly in both hind legs with a total of 20 mg BSA/animal mixed with equal volumes of complete Freund's adjuvant (Difco Laboratories), bled 10 days later, reimmunized the next day (same dose and route) with BSA mixed with incomplete Freund's adjuvant (Difco Laboratories) and bled again 10 days after reimmunization. One non-infected rabbit and 2 infected rabbits were given similar immunizations with BSA at a total dosage of 40 mg BSA/animal.

Hemagglutinin titers were determined by mixing equal volumes of thrice washed RBC and doubling-dilutions of inactivated sera (initially diluted to 1/5) in polystyrene microtiter plates. Patterns of agglutination were determined before and after gentle swirling after 24 hours incubation at room temperature. Each serum was tested in triplicate. The role of mercaptoethanol-resistant antibody (IgG) was quantitated by the method of Scott and Gershon (1970), which involves the addition of 0.1 M 2-mercaptoethanol (2-ME) to each well, resuspension of agglutinated cells and subsequent re-determination of agglutination patterns.

Precipitin titers to BSA were determined by the Ouchterlony double diffusion technique (1964). Doubling-dilutions of serum were placed in wells cut into 1% Ionagar No. 2 (Consolidated Laboratories Inc.) opposite BSA (1 mg/ml) and precipitation bands were observed after incubation for 24 hours at room temperature. Precipitin titers were determined by recording the highest serum dilution which resulted in a detectable precipitin band, and were performed in triplicate for each serum tested.

Hemagglutinin and precipitin antibody titers are reported as $\log_{10}$ values of means of triplicate determinations $\pm$ standard deviations (s.d.).

Table 1. Effect of Trypanosoma gambiense infections in rabbits on antibody responses to bovine serum albumin.

Animal Number	Total Dosage (mg)[a]	Days Infected[b]	Precipitin Titers[c,d,e,] 1°IMM	2°IMM
511	20	---	1.00 ± .17	1.50 ± .30
500	20	125	0.10 ± .17	0.50 ± .17
512	40	---	1.20 ± .00	1.60 ± .17
501	40	125	0.20 ± .17	0.60 ± .00
503	40	125	0.30 ± .00	0.70 ± .17

[a] See Materials and Methods for details of immunization regimes.

[b] Days Infected recorded as of day 1 of immunization.

[c] Titers expressed as $\log_{10}$ values of means triplicate determinations ± s.d.

[d] Titers for infected animals significantly less ($P < 0.001$) than for values of correspondingly immunized uninfected controls.

[e] 1° IMM = primary immunization; 2° IMM = secondary immunization.

Differences in titers were considered statistically significant as the 95% confidence level ($P < 0.05$) using the Student's t-test.

RESULTS AND DISCUSSION

The effects of T. gambiense infections in rabbits upon the humoral responses to BSA are illustrated in Table 1. Both primary and secondary precipitin responses to soluble BSA were significantly ($P < 0.001$) depressed among infected animals compared to uninfected controls. Although infected animals exhibited a significant ($P < 0.01$) booster response compared to their primary precipitin responses, secondary immune titers among infected rabbits were significantly ($P < 0.01$) below even the primary responses of uninfected controls.

Prior to infection each rabbit demonstrated low, but detectable levels of antibody to human type B+ erythrocytes (Table 2). This most likely represented natural antibody to blood group antigens which immunologically cross-react with antigens of many plants and microbes (Humphrey and White, 1970). After primary and secondary immunizations, uninfected controls exhibited significant elevations in agglutinin titers. Antibody levels in control rabbits rose an average of 3-fold and 6-fold (i.e., from 1/10 to 1/80 and 1/640) during primary and secondary responses, respectively. On the other hand, infected rabbits failed to produce significant responses after a single antigen challenge. Following a booster immunization, agglutinin titers in infected animals were significantly greater than pre-infection levels, rising an average of only 2-fold (i.e., from 1/10 to 1/40). However, these values for infected animals remained significantly ($P < 0.001$) below values for correspondingly immunized uninfected control rabbits. Similar results were reported by Goodwin and associates (1972) for T. brucei infections in rabbits immunized with sheep erythrocytes.

It is now known that antibody responses to heterologous erythrocytes involved cooperation between macrophages and lymphocytes, and interactions between several types of lymphocytes, including B-cell/plasma cells, T-helper cells and T-suppressor cells (for review see Marchalonis, 1980). The immunosuppression observed in this study may be accounted for by (a) depressed antigen-processing by macrophages; (b) depressed B-cell responsiveness; (c) depressed T-helper cell regulatory ability; (d) enhanced T-suppressor cell activity; or (e) a combination of these effects. Some evidence has been presented by Loose and coworkers (1972) indicating that malarial infections in mice result in defective macrophage function. More recently, however, Cunningham and associates (1980) reported that immunosuppression in T. cruzi infections in humans was not apparently due to macrophage dysfunction, but rather to an ability of lymphocytes to respond directly to sheep erythrocytes in an in vitro assay. Furthermore, in several host-parasite relationships, suppression has been shown to be mediated by T-suppressor cells or their soluble products (Ogilvie and Wilson, 1976). It, therefore, appears likely that a combination of immunologic disruptions are induced by active parasitic infection. Interestingly, immune competence to heterologous erythrocytes has been demonstrated to be rapidly restored within several days of trypanocidal chemotherapy (Murray et al., 1974 and Ackerman and Seed, 1976b).

Scott and Gershon (1970) reported that treatment of antisera with 2-ME revealed the relative roles of IgM (2-ME sensitive) and IgG (2-ME resistant) in the hemagglutination assay. In this study significant ($P < 0.05$) hemagglutinin responses were detectable for each infected rabbit between the primary and secondary immunization for the 2-ME resistant antibody, IgG (Table 2). This suggests that the IgG synthetic mechanism, believed to play a major role in secondary immune reactions (anamnesia). was not impaired or at least not to the same degree, as the IgM synthetic mechanism. The IgM levels of infected animals and humans can increase manifold (up to 20-fold) and it is now known that trypanosomes secrete a non-specific B-cell mitogen, which predominantly affects IgM-producing cells (Hudson et al., 1976). This also may account for the observed immunosuppression, since in the presence of B-cell mitogens, antigen-reactive B-cells temporarily lose their capacity to respond to antigenic challenge (Diamanstein et al., 1976).

Table 2. Effect of Trypanosoma gambiense infections in rabbits on on antibody responses to human type B+ erythrocytes.

Animal Number	Route of Immunization[a]	Days Infected[b]	Hemagglutinin Titers[c,d] PRE-INF	1°IMM	2°IMM	2-ME Hemagglutinin Titers[c,d,e] PRE-INF	1° IMM	2°IMM
513	IV	---	0.90±.17	2.20±.30	2.91±.17	0.70±.00	1.40±.35	1.70±.17
504	IV	125	1.00±.30	1.10±.17	1.30±.00	0.80±.17	0.90±.17	1.22±.17
514	IV/IP	---	1.10±.17	1.80±.17	2.61±.35	0.80±.17	1.40±.35	1.80±.17
506	IV/IP	125	1.00±.30	1.20±.17	1.50±.17	0.90±.17	0.70±.00	1.30±.00
508	IV/IP	125	1.00±.00	1.30±.30	1.40±.17	0.70±.00	0.90±.00	1.20±.17

[a] See Materials and Methods for details of dosages and time courses of intravenous (IV) and intraperitoneal (IP) immunizations.

[b] Days Infected recorded as of day 1 of immunizations

[c] Titers expressed as $\log_{10}$ values of means of triplicate determinations ± s.d. Determined pre-infection (PRE-INF), after primary (1°IMM) and secondary (2°IMM) immunization.

[d] Titers significantly less ($P < 0.001$) for infected animals compared to values for correspondingly immunized uninfected controls.

[e] Performed according to Scott and Gershon (1970).

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The Use of Research Reactors in Educational Programs in Science

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ABSTRACT

The University of Virginia Reactor Facility is widely used to support educational programs in science at universities and colleges in Virginia. This work is supported by the U. S. Department of Energy under the Reactor Sharing Program.

The University of Virginia Reactor Sharing Program consists of two parts. First, students from area colleges may visit the Reactor Facility to perform experiments concerning the characteristics of radiation and radioactive decay, radioisotope applications in science and industry, and reactor operation. Secondly, the reactor and counting facilities may be used to support research, primarily in the area of neutron activation analysis of environmental and biological samples.

Specific experiments and previous research projects are discussed. Other colleges are encouraged to participate in the Reactor Sharing Program.

Introduction

Many people believe that university owned research reactors are used primarily to support educational programs and research in nuclear engineering. While these are major functions many research reactors such as the University of Virginia Reactor (UVAR) are extensively used to support educational programs in other areas such as biology, chemistry and physics.

The versatility of research reactors in contributing to educational programs in science, and other areas, has been recognized by the U. S. Department of Energy (DOE). Specifically, DOE has established a Reactor Sharing Program which provides financial support for the use of research reactors in the educational programs of universities not owning reactors.

The Reactor Sharing Program was first instituted at the University of Virginia Reactor Facility in 1978. Since that time over 300 students have participated in experiments or research under the Reactor Sharing Program. These participants came from ten Virginia universities and colleges.

The Reactor Sharing Program at the University of Virginia has two major components. First, advanced undergraduate and graduate classes from area colleges and universities visited the Facility to perform experiments in nuclear engineering and physics which would not be possible at the user institution. Second, the neutron activation analysis facilities have been made available for research by faculty and students from user institutions. Examples of these activities are discussed in the following sections.

Student Participation in Experiments

A major portion of the Reactor Sharing Program involves groups of students visiting the Nuclear Reactor Facility to perform experiments involving the use of radioisotopes or equipment not commonly available. A summary of the colleges and universities participating in this portion of the program is provided in Table I.

The most common experiments fall into three general areas. These are (a) radiation and radioactive decay; (b) radioisotope applications in science and industry; (c) and reactor operation. A brief description of several of the available experiments is provided in Table II. In addition, special experiments may be arranged to meet the needs of classes in biology, chemistry and physics.

The use of neutron activation analysis for identification of the elemental composition of materials has been the most popular experiment. This is a result of the wide application of neutron activation analysis for research in many areas of science. Neutron activation techniques and applications are discussed in the following section. In addition to learning how to use neutron activation analysis, the students also increased their understanding of radioactive decay and interaction of radiation with matter during this experiment.

The second most requested experiment involved measurements of the decay of radioactive isotopes. The half-life of various short lived reactor produced isotopes, such as Na-24 are determined. The decay of one isotope into another radioactive isotope may also be measured to demonstrate the concept of decay chains.

In all cases, the University of Virginia supplied background information to the course instructors who used the material to prepare the students for the visit to the Reactor Facility. Once at the Reactor Facility, the students performed the experiments under the direction of the reactor engineer or faculty.

Most faculty members and students participating in these experiments have stated that they were an important addition to their classes. The positive impact of these experiments is also indicated by the relatively large number of classes making repeat visits and an approximately 60 percent increase in student participation during the second year of the program.

TABLE I
SUMMARY OF PARTICIPATION IN THE REACTOR SHARING PROGRAM
AT THE UNIVERSITY OF VIRGINIA REACTOR FACILITY

University or College	Discipline	Number of Visits
Sweet Briar College	Chemistry	7
Lynchburg College	Chemistry	3
Virginia Military Institute	Chemistry	3
James Madison University	Physics	2
James Madison University	Biology	1
Mary Washington College	Physics	2
Emory and Henry College	Physics	1
Hampton Institute	Physics	1
Longwood College	Physics	1
Randolph Macon College	Physics	1
Roanoke College	Physics	1

Research Projects Under the Reactor Sharing Program

A second objective of the Reactor Sharing Program is to allow the use of the nuclear reactors and counting facilities for research projects. Some experiments have been performed to determine the effects of radiation on materials. However, the major use has been in the area of neutron activation analysis (NAA).

Neutron activation analysis is the process by which a sample of unknown composition is placed in a neutron flux in the research reactor. The elements in the sample interact with the neutrons which transform a small amount of each element in the sample into radioactive isotopes. The quantity of each isotope produced is established by the amount of each element present in the sample, the level of the neutron flux, and the irradiation time.

Once produced, each of the radioisotopes emits characteristic gamma rays by which the elements in the sample can be identified. When the sample is counted on sensitive solid state radiation detectors the precise amount of each element can be determined.

At the University of Virginia we are currently able to analyze a sample for over 50 different elements. This analysis is expedited by the use of a dedicated computer which calculates the chemical composition directly from the gamma ray spectrum and initial data concerning the sample mass and irradiation conditions. The precision of our method is usually within 10% of actual composition but this may vary with each sample due to differing sample geometries and other variables.

Some of the advantages of NAA over other identification methods are that the sample is not destroyed, very small samples may be analyzed and samples of all descriptions may be used. Solids, liquids, biological materials, sluries, metals or mixture of these may be analyzed to determine

their elemental composition. The short time needed for analysis is also an advantage of NAA. Many samples may be analysized in a single day and on short notice if required. The cost of such analysis to also quite reasonable when compared to other multielement analysis methods.

A major portion of the research completed under the Reactor Sharing Program was performed by students from James Madison University under the direction of Dr. John R. Gordon. The research supported under this program included determination of trace metals in xylem tissue using neutron activation analysis. This work was intended to determine whether the level of trace elements in the growth rings of trees can be related to the levels of the elements existing in the environment during the period of growth. This information would be particularly valuable in determining the level of long term environmental pollution.

The research did develop a satisfactory method for determining the concentration of trace elements in xylem tissue. Information concerning the applicability of the method to long term pollution studies was also

TABLE II
EXPERIMENTS UNDER THE UNIVERSITY OF VIRGINIA
REACTOR SHARING PROGRAM

A. RADIATION AND RADIOACTIVE DECAY OF ISOTOPES

1. Radiation Counting Statistics

Demonstration of the random nature of radioactive disintegrations at both low and high disintegration rates. Using a multiscaler, a series of counts are taken which approach a Poisson distribution. A second series are taken which approach a Gaussian distribution.

2. Radioisotope Decay and Half-Life Determination

Demonstration of radioactive decay and determination of half-life of a reactor produced a short-lived isotope using a multiscaler. More complex decay chains may also be demonstrated, such as decay of two isotopes with differing half-lives or decay of two isotopes, one of which decays to the other.

3. Types of Radiation

Characterization of different types of radiation including determination of alpha and beta energy spectra using silicon surface barrier devices and gamma spectra using either a NaI scintillator or a GeLi detector. Effectiveness of materials for shielding each radiation type may also be demonstrated.

4. Radiation Intensity and Shielding

Demonstration of the decrease of radiation as a function of the inverse square of distance from the radiation source. Determination of source activity from measured dose rates and energy and effectiveness of radiation shields may also be included.

Table II (cont.)

5. Gamma-Gamma Coincidence Techniques

Demonstration of angular correlation of gamma rays from cobalt-60 and of annihilation radiation from sodium-22. The absolute activity of sodium-22 may also be determined.

6. Binding Energy of Last Neutron in Deuterium and Mass of a Neutron

Measurement of the energy of the hydrogen neutron capture gamma ray gives the binding energy of the neutron and allows the calculation of the mass of a neutron.

B. RADIOISOTOPE APPLICATIONS IN SCIENCE AND INDUSTRY

1. Neutron Activation Analysis

Demonstration of trace element analysis using neutron activation analysis. A sample is activated in the UVAR and its constituents determined from the nature of its radioactive decay. Activation analysis of a coin, lipstick, hair, environmental samples, and other samples may be performed.

2. X-Ray Fluorescence Analysis

Demonstration of the chemical analysis of a thin sample using an Am-241 x-ray exciter source and a GeLi low energy photon spectrometer. The x-ray spectrum measured from the material is used to determine the chemical composition of the surface.

3. Industrial Applications of Radioisotopes

Demonstration of the use of radioisotopes in industrial applications, such as thickness gauging, liquid level sensing and flow detection using beta, gamma and neutron sources.

C. REACTOR EXPERIMENTS

1. Approach to Critical

Demonstration of the subcritical multiplication of neutrons until a self sustaining fission reaction is obtained.

2. Reactor Dynamics and Safety Systems

Demonstration of changes in reactor power resulting from changes in control rod position. Calibration of control rods and demonstration of reactor safety systems.

3. Decay Heat Following Reactor Shutdown

Measurement of heat generation from fission and fission product decay following a reactor shutdown. Measurements are taken from nuclear instrumentation and primary system heat balance.

developed. This study was reported in the thesis "Methodology for Multi-element Neutron Activation Analysis of Trace and Minor Elements in Xylem Tissue" by P. W. Marshall of James Madison University and was presented at the Virginia Academy of Science 58th Annual meeting in May 1980.

Neutron activation analysis services provided under the Reactor Sharing Program have also supported the following research projects:

"Metal Content in Lung Tissue of Indicator Species Near Interstate Highway", Margaret A. Gordon, James Madison University.

"Trace Element Analysis of Airborne Particulates", John R. Gordon, James Madison University.

"Effect of Cadmin on Hypertension in Rats", Margaret A. Gordon, James Madison University.

"Determination of Trace Elements in Archeological Materials", Clarence Geier, James Madison University.

In summary, the University of Virginia Reactor Facility is widely used to support educational and research programs in science at several colleges and universities in Virginia. Under the Department of Energy Reactor Sharing Program, there is no charge to the participants in the program for the use of the equipment or personnel.

Other universities are encouraged to participate in this program. Visits or research can be arranged by contacting either of the authors.

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Environmental Perceptions and Management Preferences of Lake Property Owners in Virginia

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ABSTRACT

This study investigated the basic understanding of lake property owners and their potential role in formulating lake management policies. A mail questionnaire was used to collect data on the environmental perceptions and management preferences of lake property owners. Solitude, natural beauty, and water-based recreation were the principal reasons cited for lake property ownership. The subjective assessments of lakeshore residents accurately reflected the prevailing environmental conditions. Property owners' selection of management activities was appropriate for the existing conditions and directly related to their environmental perceptions. Landowners were particularly sensitive to water clarity, sedimentation, and erosion problems. They strongly supported the proposed management activities and were willing to restrict their recreational pursuits to protect environmental quality. The results suggest that lake management policy decisions should be based on the integration of both sociological and limnological data.

INTRODUCTION

Over the past decade the demand for lakeshore property and water-based recreation has intensified. Lakes of all dimensions are deteriorating in water quality, fisheries, shoreline integrity and other environmental characteristics. Simultaneously, conflicts between various user groups of multipurpose recreational lakes are increasing in frequency and intensity. Frustrated by the absence of objective information and the inadequacy of simplistic solutions, owners of lakeshore property seek comprehensive professional guidance. Since environmental quality is affected by a variety of physical, chemical, biological, and sociological factors, lake managers must collect and synthesize both limnological and sociological data. Developing a systematic approach to measuring prevailing physio-chemical and biological conditions of a lake is routine to most lake analysts. However, assessment of lake owner perceptions, attitudes, expectations, and recreational uses of lakes in conjunction with limnological measurements is not standard practice. This paper demonstrates one approach to gathering and using sociological information to help establish priorities, objectives, and management operations. Our belief is that recommendations founded on the integration of sociological and limnological information will more readily be accepted and applied by lake property owners than recommendations based solely on limnological data.

METHODS

The information presented in this study was collected as part of a comprehensive limnological and management evaluation of Lake Caroline. Located in eastern Virginia, Lake Caroline is an artificial 280 acre mainstream impoundment that was filled in 1967. At the time of the study 114 single family dwellings existed at the lake, 37 of these served as full-time residences.

Except for personal interviews with fishermen to determine angling success, the sociological information was obtained by a mail questionnaire sent to 114 homeowners. The 50-item questionnaire was designed and pretested to reduce ambiguity. Three follow-up reminders were mailed at monthly intervals to all eligible respondents. Homeowners were asked directly why they purchased lake property and to detail their uses of the lake and their property. A five-point, modified semantic differential scale was used to measure reactions of the respondents to 16 contrasting pair of stimulus words or phrases relating to water quality, and nuisance organisms. A five-point Likert scale, ranging from very necessary to very unnecessary, was used to measure property owner's attitudes toward the need for each of the 15 proposed lake management activities. Adverbial qualifiers such as "very" and "extremely" were incorporated to encourage response polarity. Questions were designed to permit comparison of perceptions with actual measurements of lake characteristics.

RESULTS AND DISCUSSION

From a total of 114 eligible respondents, 79 usable questionnaires (69%) were returned. The respondents (household heads) were predominantly middle-age, affluent, professional or management level employees. The majority (88%) were married and nearly half (48%) had one or more children in the family. Most respondents, including seasonal residents, spent more than 30 days per year at the lake and were actively involved in formulating lake management policies. More than half of the respondents (59%) were serving as members on committees within the Lake Caroline Property Owners Association.

Primary Purpose for Lake Property Ownership

The majority of respondents (54%) selected solitude and natural beauty as the principal reason for purchasing lake property (Figure 1). Twenty-two percent were primarily motivated to buy lake property for outdoor recreation; 19% purchased land for water-based recreational activities (swimming, boating, and fishing), while 3% acquired property for landbased recreation (hiking, tennis, bicycling). Only 6% of the respondents invested in lake property predominantly for economic rewards. The remaining 18% of the respondents listed other factors including inheritance, retirement, security, sales pressure, and social activities as the major reasons for lake property ownership.

Clearly, most lake property owners place a high value on the peacefulness and natural beauty normally associated with lake environments. Klessig and Yanggen (1975) found that a majority (62%) of Wisconsin lake property owners also considered solitude and natural beauty the most important reason

for lake property ownership. Marans and Wellman (1978) reported that the major attraction for homeowners on lakes and rivers in northern Michigan was the peace and natural setting of the area. In both of these studies, as in this survey, the wide range of recreational opportunities available were the second most important purpose for lake property ownership. While these primary motives are not particularly surprising, they do reflect the needs underlying people's choices and the relative importance of lake environments in providing tranquility, natural beauty, and recreational opportunities.

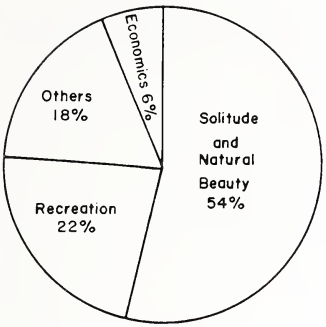
Participation in Water-based Recreation

The proportion of time spent actively engaged in each of the four major water-based recreational activities (swimming, waterskiing, boating, and fishing) is illustrated in Figure 2. A total of 25,895 recreational hours were logged for 1194 lake property owners, their family members, and guests during the summer months (June through August). The most popular sport, swimming, accounted for 45% of the recreation time. The majority of the respondents (81%) swam at least once in the lake waters and most swimmers (71%) preferred natural lake waters to the artificial pool. The remaining water-based recreational use hours were spent waterskiing (23%), boating (16%), and fishing (14%).

Since previous studies have indicated that participation in recreational activities is strongly related to accessibility or availability of the resource (Marans and Wellman 1978), we expected lake property owners to participate more actively in water-based recreation than a representative sample of the United States population as a whole. Compared to the national average (U.S. Department of Interior 1979), almost twice as many Lake Caroline property owners participated in swimming (natural waters), waterskiing, and non-powerboating (Table 1). The proportion of our respondents participating in artificial pool swimming, fishing, and powerboating was about equal to the national average. These results further confirm other reports of close association between participation and access.

Perceptions of Environmental Conditions

Although lake property attracts individuals seeking peace, solitude, natural beauty, recreational opportunities, economic rewards, and other benefits of riparian property, how lake property owners evaluate the prevailing environmental conditions on the lakes they regularly use is poorly known. In an attempt to determine lake property owner's attitudes and perceptions of their immediate lacustrine environment, respondents were asked to assess a series of 16 major environmental attributes related to water quality, shoreline development, neighborhood conditions, recreational pressure, and nuisance organisms. The respondents were asked to rate each environmental condition on a five-point scale. One end of the scale was represented by a positive descriptor (i.e. clean water), while the other end of the scale was represented by a negative



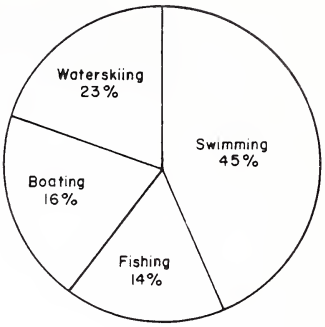


Figure 1 to the left shows primary purpose for lake property ownership expressed as the percentage of total property owners responding (n = 79). Figure 2 to the right shows participation in water-based recreational activities expressed as the percentage of total recreational hours logged during June, July, and August for all property owners (n = 25,895 hours).

descriptor (i.e. polluted water); the midpoint indicated a neutral response. In order to avoid a column-type response bias, the positive and negative descriptors were randomly assigned positions (left or right) on the questionnaire and subsequently unscrambled for analysis and presentation.

Perceptions of water quality, shoreland conditions, neighborhood quality, recreational pressure, and nuisance organisms are presented in Table 2. Respondents appeared most satisfied (highest proportion of positive responses and lowest proportion of negative responses) with neighborhood quality, water purity, swimming pressure, and shoreland development, and least satisfied with shoreland erosion, fishing quality, and aquatic pest population levels. Although a majority of the respondents (75%) described their lake waters as clean, they were less satisfied with water clarity. About one-third of the respondents rated lake waters as colored, but were able to distinguish polluted water (in a chemical sense) from colored (turbid) water (in a physical sense). Shoreland erosion was viewed as the single most serious problem affecting the lake environment. Recreational pressures, notably powerboating and waterskiing, were not viewed as excessive by most property owners.

Subjective Perceptions vs Objective Measurements

To determine the degree to which lake property owner's perceptions of their environment correspond to the actual conditions, we compared our respondent's subjective assessments to a series of 19 objective measurements (mean summer values) characterizing water quality, shoreland conditions, recreational pressure, and fishing quality (Table 3). Most objective measurements appeared to correspond closely with the lake property owner's subjective evaluations. For example, the relatively

Table 1. Participation in water-based recreational acitvities: comparing Lake Caroline, Virginia with a representative sample of the United States population (percentage of participants).

Activity	Lake Caroline Virginia 1978 (% participants)	U.S.[1] 1977 (% participants)
Swimming:		
Natural waters	81	46
Artificial pool	57	63
Fishing	60	53
Power boating	28	33
Other boating	40	26
Waterskiing	29	16
N	1144	4029

[1]Heritage Conservation and Recreation Service (1979).

low water transparency values (3.1 feet), high water color (54 PT units), and high proportion of shoreland area actively eroding (40%), were reflected in the majority of our respondent's subjective judgements of moderately low water clarity and heavy shoreland erosion. Objective measurements of recreational pressure and shoreland development also corresponded to landowner's perceptions of relatively light recreational pressure and undeveloped shoreland. Lake property owner's opinions that fishing quality was poor, however, did not agree with the objective measurements. The actual harvest rates and catch per unit effort values, particularly of largemouth bass (the most preferred species) indicated very high angling success.

Perceptions of Lake Management Needs

One of the most critical aspects of inland lake management is selecting the most suitable management alternatives to implement. To gain insight into lake property owner's perceptions between environmental conditions and management needs, our respondents were asked to rate 15 proposed lake management activities on a five-point scale ranging from very necessary to very unnecessary. As shown in Table 4, virtually all of the suggested management activities were considered very necessary or necessary by the majority of the respondents. Monitoring water quality was viewed as the single most important lake management need. Controlling water levels, sedimentation, shoreland erosion, pollution, and education (understanding lake problems) were judged as necessary management activities by more than 90% of the respondents. Controlling leaf burning, lawn fertilization, and lawn irrigation were considered the least appropriate lake management activities.

Respondent's evaluation of lake management activities were strongly related to their perceptions of the prevailing environmental conditions. For example, those management activities (monitoring water quality,

Table 2. Lake property owners' perceptions of water quality, shoreland conditions, neighborhood conditions, recreational pressure, and nuisance organisms on a five point scale (percent of respondents).

Description	Positive Responses 1	2	Neutral 3	Negative Responses 4	5	Description
Water Quality:						
Clean	24	51	21	4	0	Polluted
Clear	8	27	34	21	10	
Shoreland Conditions:						
Undeveloped	13	36	51	0	0	Colored
Many Trees	26	25	40	6	1	Few Trees
Little Erosion	9	11	36	28	16	
Neighborhood Quality:						
Attractive	46	35	17	0	2	Unattractive
Quiet	40	35	18	4	3	Noisy
Private	26	40	30	4	0	Little Privacy
Recreational Pressure:						
Light Powerboating	9	13	48	24	6	Heavy Powerboating
Light Waterskiing	11	14	46	24	5	Heavy Waterskiing
Light Swimming	28	31	28	11	2	Heavy Swimming
Light Fishing	12	24	59	3	2	Heavy Fishing
Excellent Fishing	3	18	40	29	10	Poor Fishing
Nuisance Organisms:						
Few waterweeds	6	20	36	15	23	Many Waterweeds
Few Insect Pests	7	28	30	16	19	Many Insect Pests

controlling shoreland erosion, sedimentation, and water level fluctuations) that represented potential solutions to the most serious environmental threats (erosion, sedimentation, pollution, and water clarity) were viewed as necessary or very necessary by more than 90% of the respondents. Since recreational pressures (waterskiing, powerboating, swimming, and fishing) were perceived as moderately low, management activities directed at regulating these activities were not considered as necessary as the other proposed activities. While controlling leaf burning, lawn fertilization, and lawn irrigation were considered the least appropriate management activities, they can significantly reduce nutrient runoff and inhibit lake eutrophication. Apparently, the causes and consequences of accelerated eutrophication were not as obvious and, consequently, not as important to lake property owners as many of the other more highly visible lake management problems. Nevertheless, the majority of respondents enthusiastically endorsed most of the proposed management activities in proportion to their perceived needs and seemed willing to restrict their recreational pursuits to protect environmental quality.

Overall Environmental Satisfaction

Recent studies have documented that an individual's assessments of his residential environment is an important component of his views on the quality of his life (Marans and Rogers, 1975). To gain an evaluation of overall environmental quality, we asked the respondents to indicate their general level of satisfaction with the existing lake environment on a five-point scale ranging from extremely satisfied to extremely

dissatisfied. Of the total 79 landholders responding to this question, 86 percent indicated that they were either satisfied or extremely satisfied, 5 percent offered no opinion, and only 9 percent were dissatisfied. It is important to note that among those landowners who expressed general dissatisfaction, the majority complained about lake association rules and regulations, particularly annual dues and assessment rates, rather than limiting their evaluation to the lake environment.

MANAGEMENT IMPLICATIONS

A number of lake management implications are suggested by the findings in this study. First, the results clearly demonstrate that lake property attracts individuals seeking peace, solitude, natural beauty, financial rewards, water-based recreational opportunities, social activities, and other attributes of lake property ownership. Obviously, then, lakes represent multi-purpose water resources that must be equitably managed to accomodate a diverse and potentially conflicting array of user interests. Lake management, in this sense, must focus on developing and enforcing reasonable regulations designed to control socially disruptive and environmentally destructive human behavior.

Second, we found that lake property owners have a substantial vested interest in protecting the aesthetic and recreational qualities of their lake, spend a considerable portion of their leisure time actively engaged in water-based recreation and, perhaps as a consequence, are particularly sensitive to potential environmental problems. Lakeshore residents and non-residents appear to hold strong, accurate opinions about what constitutes acceptable levels of water quality, shoreland development, neighborhood conditions, recreational pressure and nuisance organisms. These results serve to emphasize the potentially valuable role of property owners in developing lake management guidelines. Managers should recognize that systematic observations by lakeshore residents who regularly view their lake under a variety of circumstances can provide a reliable basis for identifying conspicuous environmental problems. Limnological evaluations should be conducted to evaluate less apparent physiochemical and biological conditions.

Third, the results indicate that lake property owner's selection of proposed lake management activities was strongly related to their environmental perceptions and appropriate to the existing conditions. Management activities aimed at controlling the most serious environmental threats were considered necessary by more than 90 percent of the respondents. Notably, protective and educational activities were more preferred than those management activities that were regulatory in nature. Monitoring water quality, for example, was viewed as the most important management activity. These findings further substantiate that lake property owner's conceptions of what constitutes the "best management practices" for their particular lake are relatively valid. Lake managers should be aware that water quality monitoring and educational programs are highly preferred and integral components of optimal inland lake management.

Fourth, our results suggest that environmental perceptions and management preferences among lake property owners were quite similar. Other researchers

Table 3. Selective objective indicators of water clarity, shoreland conditions, recreational pressure and fishing quality (mean values).

Indicator	Value
Water Quality:	
Fecal Coliform Bacteria	1/100 ml
Secchi Disc Transparency	3.1 feet
Turbidity	13 Formazin Units
Apparent Color	54 Platinum-Cobalt Units
True Color	22 Platinum-Cobalt Units
Shoreland Conditions:	
Residential Density	9 Residences/Kilometer
Undeveloped Shoreland Area	85 Percent
Shoreland Erosion Area	40 Percent
Recreational Pressure:	
Powerboating Density	0.7 Boat/Surface Acre
Powerboating Intensity	18 Hours/Acre/Year
Waterskiing Density	0.6 Waterskiiers/Surface Acre
Waterskiing Intensity	25 Hours/Acre/Year
Swimming Density	4 Swimmers/Surface Acre
Swimming Intensity	56 Hours/Acre/Year
Angler Density	1 Angler/Surface Acre
Angler Intensity	38 Hours/Acre/Year
Fishing Quality:	
Harvest Rate (Yield)	20 Pounds/Acre/Year
Total Catch Rate	3.1 Fish/Hour Effort
Bass Catch Rate	0.5 Bass/Hour Effort

have reported that environmental perceptions and sensitivities vary among swimmers, boaters, and fishermen (Ditton and Goodale 1973, Kooyomjian and Clesceri 1974). Evidence to support or refute the existence of varying tolerances or sensitivities among different recreational user groups was not uncovered in this study. Our findings indicate lake property owner's attitudes toward management activities may be more consistent than expected; such conformity simplifies the development of acceptable lake management recommendations.

Finally, it appears there is a substantial need to develop comprehensive management strategies for recreational lakes. At present, most attempts at lake management focus on one of two, more or less exclusive approaches. These are: (1) externally developed management goals based largely on the objective physiochemical and biological evaluations of professional consultants (limnologists) and, (2) internally developed management based mainly on the subjective attitudes, opinions and expectations of lake property owners independent of outside experts. The first approach, typically used to "intensively" manage badly degraded lakes, primarily focuses on short-term crisis situations and is principally restorative

Table 4. Lake property owners' perceptions of proposed lake management activities ranked and expressed in order of need (percent of respondents).

Management Activities	Very Necessary or Necessary	No Opinion	Very Unnecessary or Unnecessary
Inspecting water quality	94	5	1
Controlling water levels	94	4	2
Controlling sedimentation	93	7	0
Controlling pollution	93	4	3
Understanding lake problems	91	9	0
Controlling shoreland erosion	90	7	3
Controlling waterweeds	83	9	8
Regulating waterskiing	79	15	6
Regulating pesticide use	79	19	2
Regulating horsepower	78	11	11
Stocking fish	73	17	10
Inspecting septic tanks	69	20	11
Controlling leaf burning	62	20	18
Controlling lawn fertilization	53	33	14
Controlling lawn irrigation	43	42	15

in nature. The second approach, most commonly used to "extensively" manage relatively high-quality lakes, mainly addresses social problems and is essentially protective or regulatory in nature.

Neither of these two approaches, in themselves, represent an optimum approach to lake management. In the first instance, limnological conditions are generally overemphasized, while in the second case sociological dimensions are accentuated. Moreover, management policies established strictly by outside consultants are not likely to be widely accepted or vigorously implemented unless they correspond with the lake property owner's views or are accompanied by intensive educational programs. On the other hand, the perceptions of lake property owners are often limited in scope and should not be the sole determinants for formulating lake management policy. David (1971), for example, demonstrated that public perceptions of water quality were restricted to only highly visible indicators (surface scum, algae blooms) that were readily detected by the human sensory system. Clearly, a more balanced approach, incorporating both the subjective assessments of lakeshore residents and an objective limnological evaluation by professionals, represents the most rational way to address recreational lake management.

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Exposure-Induced Differences in the Vegetation, Soils, and Microclimate of North- and South-Facing Slopes in Southwestern Virginia

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ABSTRACT

The vegetation of two forest communities on contrasting north- and south-facing slopes of a spur ridge of Salt Pond Mountain in southwestern Virginia was intensively sampled to determine differences in composition, structure, and diversity directly related to slope exposure. In addition, data were obtained for the soils and microclimate associated with each site. Major differences in distribution and abundance on the two exposures were noted for a majority of the 105 taxa present, resulting in appreciable compositional differences for all strata of vegetation. Density, diversity, and basal area were generally higher for the north slope community, and available data suggest that these differences can be attributed to a topographic moisture gradient. Statistically significant differences exist for a number of soil characteristics, all of which seem to be related to a greater accumulation of organic matter on the south slope. Differences in microclimate are most pronounced early in the growing season, with soil temperature at a depth of 2 cm and maximum air temperature the factors showing the greatest differences.

INTRODUCTION

The present study was concerned with providing quantitative data on exposure-induced differences in the vegetation, soils, and microclimate of contrasting north- and south-facing slopes in southwestern Virginia. Other published descriptions of the vegetation of the general study area (Braun, 1950; McCormick and Platt, 1970; Stephenson, 1974; Adams, 1976; McEvoy et al., 1980) have reported differences in community composition seemingly related to topographic gradients, but the vegetation-environment relationships noted were inferred from field observations. Hence, quantitative data supporting the environmental differences which exist from site to site are largely lacking. In the present study the vegetation of two

adjacent upper slope communities was intensively sampled. In addition, an effort was made to quantify as many environmental parameters as possible in order to actually document the environmental differences associated with these two communities. The specific objectives were to (1) examine in detail the structure and composition of the plant communities on the two slopes, (2) obtain quantitative data on the physical and chemical characteristics of the soils associated with the two communities, and (3) assess differences in the microclimates of the two sites for an entire growing season.

The study site is located on Salt Pond Mountain in Giles County in southwestern Virginia, which is within the Valley and Ridge physiographic province of the southern Appalachian Mountains. Braun (1950) included the area within the Ridge and Valley Section of the Oak-Chestnut Region. The study site lies close to the western boundary of the Oak-Chestnut Region where the latter gives way to the Mixed Mesophytic Region. The major species of trees composing the forests of the region are various species of oak, of which Quercus prinus (chestnut oak) and Q. rubra (red oak) are the most important. Castanea dentata (American chestnut), formerly a codominant or dominant species in the area, was almost completely eliminated during the first half of this century by chestnut blight (Stephenson, 1974).

Climatological data for the Salt Pond Mountain area are limited, but data from a U. S. Weather Bureau station established in November, 1971 at the University of Virginia Mountain Lake Biological Station on Salt Pond Mountain give some indication of the climate of the study area. The average annual precipitation is 149.4 cm. The mean annual temperature is 8.4 C. The lowest temperature of record is -30.6 C, and the record maximum temperature is 27.8 C. The average frost-free season is about 142 days (U. S. Department of Commerce, Weather Bureau, 1972-1975).

MATERIALS AND METHODS

Quantitative data on vegetation, soils, and microclimate were collected during the summers of 1974, 1975, and 1976 from north- and south-facing slopes of War Spur Ridge, a spur ridge that extends northeastward from the main body of Salt Pond Mountain. The two study areas were about 300 meters from each other, on opposite sides of the ridge, and in areas of relatively uniform topography. The vegetation at each site was considered representative of that on the entire slope. The study area on the north-facing slope (aspect 10° N) was situated about 75 meters in linear distance below the crest of the ridge on a 28 percent slope. The study area on the south-facing slope (aspect 160° S) was located about 100 meters below the crest of the

ridge on a 36 percent slope. The elevation of the crest of the ridge at a point directly above the two study areas is approximately 1150 meters above sea level.

Vegetation in each study area was sampled with a series of nested quadrats. Quantitative data for the tree (>10 cm DBH) and small tree (<10 but >2.5 cm DBH) strata were gathered in a single 20 x 50 meter (0.1 ha) rectangular quadrat laid out with its long axis parallel to the contour of the slope. Counts were made of saplings (individuals of tree taxa <2.5 cm DBH but >0.5 m high), seedlings (individuals of tree taxa <0.5 m high), and shrubs (other woody plants including vines) in ten 2.5 x 5 m quadrats. Canopy coverage of herbaceous plants was recorded in 50 rectangular quadrats, each 0.2 x 0.5 m, spaced at regular intervals throughout the 0.1 ha quadrat. Cover values were estimated with a cover class rating scale (Daubenmire, 1968). In addition, an effort was made to record every vascular plant taxon present in the 0.1 ha quadrat. Species were combined in several genera (e.g., Prenanthes, Rubus, etc.) because of the impossibility of distinguishing species by purely vegetative characteristics. Plant identifications and nomenclature follow Radford et al. (1968).

From the quadrat data, importance value indices (Curtis and McIntosh, 1951) were derived for each taxon in a given stratum. These were based on the relativized measures computed for a given stratum and are expressed as a percentage for each taxon. For example, importance values for trees are one-half the sum of relative basal area and relative density. The two communities were also compared on the basis of the distribution of individuals among the taxa present in each stratum. Diversity indices for each stratum were calculated with the formula described by McIntosh (1976).

Analyses of the chemical properties of the soils on the two slopes were carried out on 10 samples from each study area. These were taken from the zone 1-10 cm below the litter layer, usually from the A1 or upper A2 horizons where these could be identified. Soil samples were returned to the laboratory, where preliminary analyses of pH were carried out. Later, analyses of organic matter, phosphoric acid, calcium, magnesium, potassium, and soluble salts were carried out by the Soil Testing Laboratory at Virginia Polytechnic Institute and State University, by the procedures outlined by Alley and Hawkins (1972). Analyses of carbon and nitrogen by combustion gas chromatography were performed by the Chemistry Department of Virginia Polytechnic Institute and State University. Additional soil samples for moisture determination were collected on twelve dates during the study, including two periods (August 2-24, 1975 and April 30-June 4, 1976) when samples were taken at weekly intervals. Separate samples were taken from two to four locations on each slope on each date. These were sealed in plastic bags to prevent water loss. In the laboratory, samples were weighed, oven-dried at 105 C for 48 hours, and

reweighed. Soil moisture was calculated as a percentage of the dry weight of the soil. Soil pits were dug at three locations in each study area, and samples of mineral soil were collected from a depth of 10-15 cm. In the laboratory, replicates of the fraction less than 2 mm in diameter were analyzed for soil texture by the hydrometer method (Bouyoucos, 1951). Soil cores for determination of bulk density were also collected from four locations on each slope.

Near the center of each of the two study areas a maximum-minimum self-registering thermometer was positioned one meter above the ground to obtain data on air temperature. Readings of maximum, minimum, and early afternoon air temperature were taken at weekly intervals from June 14-October 4, 1975 and March 26-July 2, 1976. Measurements of soil temperature were made at each site with three thermistor probes. These were buried at depths of 2, 10, and 20 cm below the soil surface and were located under what were considered to be comparable situations of canopy cover on the two slopes. Maximum-minimum thermometers and thermistors were calibrated both before and after their use in the field with a precision mercury-in-glass thermometer. During the entire study, an effort was made to read all instruments at approximately the same time of day on each visit.

RESULTS AND DISCUSSION

A total of 105 taxa was recorded from the two study areas. Forty-one taxa were present only in the community on the south slope, 35 were found only in the community on the north slope, and 29 were recorded from both communities. Appreciable differences in abundance for the two exposures were displayed by a large percentage of the taxa that occurred in both communities. As a general observation, most of the taxa that were leading dominants on one slope were either absent or relatively uncommon on the other slope. Among the more important herbs, those with an importance value of 2.0 or greater in either community, only Solidago curtisii, Stellaria pubera, and Uvularia perfoliata displayed roughly comparable levels of abundance on both exposures. For the shrubs, only Vaccinium vacillans was present in appreciable numbers on both slopes, but the relative importance of this species was considerably higher in the community on the south slope. Castanea dentata was the only tree species which did not show some evidence of an affinity for one of the two exposures.

Six species were represented in the tree stratum of the two communities. Quercus rubra, with an importance value of 57.5, was the most important species in the community on the north slope, with Acer rubrum (21.4) and Q. prinus (10.0)

the only other species with importance values greater than 10. For the community on the south slope, Carya glabra (60.9) was the leading dominant, with Q. prinus (26.0) and Q. alba (10.8) next in importance. Density of trees (61 and 50 stems/0.1 ha), basal area (312.2 and 304.3 dm^2/0.1 ha), and diversity (0.44 and 0.34) were all higher for the community on the north slope than for the community on the south slope.

A total of ten species was found in the small tree stratum of the two communities, including four species (Quercus velutina, Hamamelis virginiana, Castanea dentata, and Amelanchier arborea) that were not present in the tree stratum. Acer rubrum (63.7) and A. pensylvanicum (21.9) were the leading dominants in the small tree stratum on the north slope, whereas Carya glabra (53.6), Q. rubra (23.8), and Castanea dentata (11.3) had the highest importance values in this stratum on the south slope. Density (102 and 94 stems/0.1 ha) and basal area (28.1 and 23.2 dm^2/0.1 ha) displayed a pattern similar to that of the tree stratum, with higher values recorded for the north slope. However, the pattern of diversity was different, with the value for the south slope (0.43) higher than that for the north slope (0.36).

The sapling stratum consisted of ten species, of which five (Robinia pseudoacacia, Sassafras albidum, Tsuga canadensis, Magnolia acuminata, and Betula lenta) were not found in either of the preceding strata. Castanea dentata (40.3 N and 37.6 S) was the leading dominant on both exposures. Acer pensylvanicum (22.4), Betula lenta (15.0), A. rubrum (11.9), and Magnolia acuminata (10.4) were the other more important species in the north slope community, whereas Sassafras albidum (34.1) and Robinia pseudoacacia (17.0) were the other important components of the sapling stratum on the south slope. The values for both density (33 stems/0.01 ha) and diversity (0.60) of saplings were higher for the community on the north slope than for the south slope community (27 stems/0.01 ha and 0.54).

Sixteen species were found in the tree seedling stratum. Only one species (Tsuga canadensis) present in any of the three preceding strata was not represented among the seedlings tallied in the two communities, and two additional species (Sorbus americana and Prunus serotina) not previously encountered were recorded in this stratum. Sassafras albidum (41.2) was clearly the dominant taxon in the south slope community, with Carya glabra (18.9), Quercus alba (11.5), Q. rubra (8.9), and Q. prinus (8.0) also important. Quercus rubra (28.9), Acer pensylvanicum (20.6), A. rubrum (15.8), and Betula lenta (9.3) were the most important components of

the seedling stratum on the north slope. Density of seedlings was appreciably higher on the north slope (301 stems/0.01 ha) than on the south slope (175 stems/0.01 ha). Diversity displayed a similar pattern, with the value for the north slope (0.51) higher than the corresponding value for the south slope (0.39).

Ten taxa were represented in the shrub stratum. Rhododendron calendulaceum (30.8), Vaccinium erythrocarpum (21.0), Rubus spp. (18.9), Menziesia pilosa (11.8), and V. vacillans (9.3) were the most important shrubs in the community on the north slope, whereas Vaccinium vacillans (65.8) and Rosa carolina (11.4) were the only taxa occurring in appreciable numbers on the south slope. Vaccinium stamineum was fairly abundant in one part of this community but was not encountered in any of the quadrats used to sample the shrub stratum. The total density of shrubs on the north slope (211 stems/0.01 ha) was considerably higher than the corresponding value for the south slope (49 stems/0.01 ha). Diversity of the shrub stratum on the north slope (0.56) was also appreciably higher than that for the south slope (0.20).

A total of seventy-eight taxa was present in the herb stratum. The most important herbs on the north slope, in order of decreasing importance values, were Prenanthes spp., Viola rotundifolia, Disporum lanuginosum, Aster divaricatus, Medeola virginiana, Dioscorea villosa, Polygonatum biflorum, Stellaria pubera, Convallaria majalis, Solidago curtisii, Uvularia perfoliata, and Lilium superbum. The most important herbs on the south slope were Galium latifolium, Desmodium nudiflorum, Viola palmata, Aster undulatus, Amphicarpa bracteata, Cimicifuga racemosa, Potentilla simplex, Panicum boscii, Solidago curtisii, Carex pensylvanica, and Coreopsis major. The total number of taxa present on the south slope (56) was somewhat higher than the number for the north slope (41), but the diversity of the herb stratum on the south slope (0.802) was only slightly higher than the value for the north slope (0.798). Total cover of herbs was appreciably higher on the south slope (71%) than on the north slope (21%).

In general, the composition of the vegetation of the two communities is not markedly different from previously published descriptions of upper slope forest communities in southwestern Virginia, although quantitative data for northern exposures and subordinate strata of vegetation are rather limited. The differences in diversity, density, and basal area noted for the two communities are consistent with trends in these structural variables found to be associated with a topographic moisture gradient in other

studies conducted in the southern Appalachian Mountains (Whittaker, 1956; Mowbray and Oosting, 1968). A tentative identification of a moisture complex-gradient is also supported by a substantial body of data on the pattern of the vegetation and general environmental characteristics of the entire Salt Pond Mountain area (Stephenson, unpublished data) which will be considered in a future paper. However, these data do not indicate that the pattern of vegetation can be correlated with variations in a single measured environmental factor (e.g., soil moisture).

Laboratory analyses of the soils on the two slopes are summarized in Table I. Differences in soil chemical and physical characteristics were tested for significance by single classification analysis of variance. The soil on both slopes is a sandy clay loam, apparently derived from Silurian sandstones and shales and with appreciable amounts of rock fragments present in the solum. As can be noted from the data given, the only physical characteristic that was found to be significantly different was the percentage of organic matter. Nine of the 10 soil samples from the south slope contained more than 15.0 percent organic matter, the maximum value that can be determined with the standard analytical procedures used by the Soil Testing Laboratory at Virginia Polytechnic Institute and State University (Alley and Hawkins, 1972). In contrast, only one of the soil samples from the north slope had a level of organic matter that exceeded 15.0 percent, and two samples had no more than 6.5 percent. Whether the higher level of organic matter in soils on the south slope is the result of a generally slower rate of litter decomposition because of differences in prevailing microclimatic conditions or the result of a difference in the annual increments of litter produced by the vegetation on the two slopes could not be assessed and thus requires additional study.

Soil moisture was relatively high on both slopes, but the mean value for the south slope (49.3%) was larger than the mean value for the north slope (43.7%). South-facing slopes are usually drier than north-facing slopes (Mowbray and Oosting, 1968), so that such a pattern would not have been expected. However, the results of the present study are similar to those obtained by Keever (1973) and Ng and Miller (1980), which suggest that under some conditions actual measurements of soil moisture may be contrary to expected values. Measurements of soil moisture taken on various dates throughout the growing season show that considerable variation exists on both slopes. However, levels of soil moisture on the south slope were always somewhat higher than those on the north slope, and both slopes tended to have somewhat drier conditions toward the

Table I. Comparison of soil physical and chemical characteristics for communities sampled on the two slopes.

PHYSICAL CHARACTERISTICS

Community	Gravel (%)	Sand (%)	Silt (%)	Clay (%)	Organic matter (%)	Bulk density (g/cc)	Soil moisture (% dry wt.)
North slope	28.9	62.8	15.1	22.1	11.1	0.61	43.7
South slope	37.6	65.9	14.0	20.1	14.9*	0.56	49.3

CHEMICAL CHARACTERISTICS

Community	Ca (ppm)	Mg (ppm)	P (ppm)	K (ppm)	C (%)	N (%)	C:N ratio	Soluble salts (ppm)	pH
North slope	135	28	111	62	9.3	0.45	20.7	356	4.0
South slope	904*	94*	84	117*	13.2*	0.47	28.0	597*	4.9*

*Significant at 0.01 level of probability

end of the growing season than near the beginning. The average values of soil moisture for samples taken late in the growing season, during a period from Aug. 2 to Aug. 24, 1975, were 39.5 percent for the south slope and 35.5 percent for the north slope. The maximum values of soil moisture recorded for any one date during the entire study were 68.4 percent for the south slope and 56.1 percent for the north slope, both recorded for samples taken on March 26, 1976. Minimum values for the two slopes were 31.5 and 30.3 percent respectively, recorded for samples taken on Aug. 24, 1975. If the compositional and structural differences in the two communities reflect a topographic moisture gradient, this is not supported by these data. However, this fact does not necessarily imply that moisture is not the single most important environmental factor, since a moisture gradient involves both soil moisture and atmospheric moisture, and the latter was not measured in the present study. Likewise, the significantly higher level of organic matter in the soils on the south slope represents a modifying factor of undetermined importance, since the water-holding capacity of a soil increases as the organic matter content increases (Brady, 1974).

When the soil chemical characteristics of the two slopes were compared, significant differences were found for the amounts of calcium, magnesium, potassium, and soluble salts present as well as for pH. All of these differences would seem to be directly related to the difference in soil organic matter that exists between the two slopes (Brady, 1974). For the most part, the values recorded for soil chemical characteristics in the present study are well within the ranges generally regarded as typical for forest soils. The values are slightly higher than those reported

for a comparable series of well-drained, upland soils in Randolph and Tucker Counties, West Virginia (Auchmoody, 1972).

Differences in soil temperature between the two slopes were greatest at the 2 cm level and, in general, decreased with increasing depth (Figures 1-3). The mean soil temperature at a depth of 2 cm was 19.5 C for the south slope and 14.9 C for the north slope, a difference which is significant at the 0.05 level of probability. For the 10 cm level, mean soil temperatures were 15.7 C on the south slope and 13.2 C on the north slope. Mean soil temperatures at the 20 cm level were 14.3 C for the south slope and 13.3 C for the north slope. Differences in soil temperature between the two slopes at all three levels were generally greater during the early part of the growing season than at any other time. Maximum differences noted during the entire study were 12.5 C at the 2 cm level, 8.0 C at 10 cm, and 3.5 C at 20 cm. All three were recorded on or before May 21, 1976, which

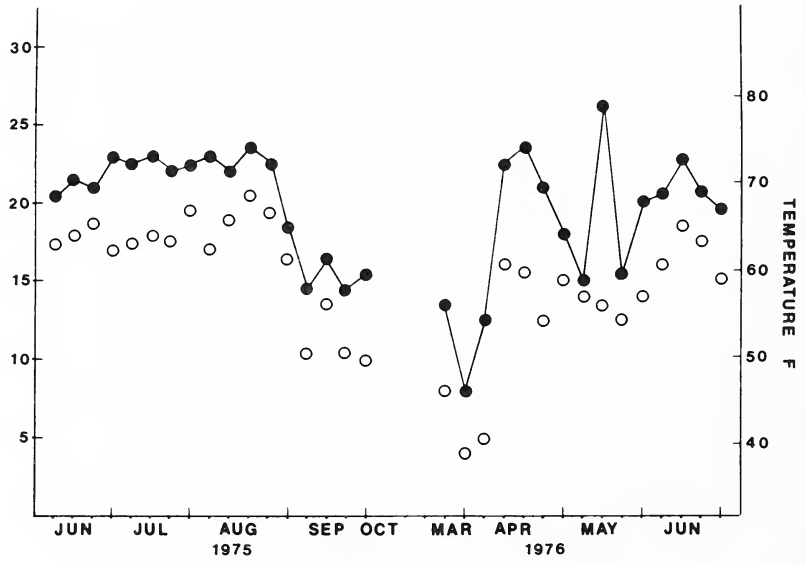

Figure 1. Soil temperature at a depth of 2 cm on adjacent north- (open circles) and south-facing (solid circles) slopes at weekly intervals during the periods of June 14 to Oct. 4, 1975 and March 26 to July 2, 1976.

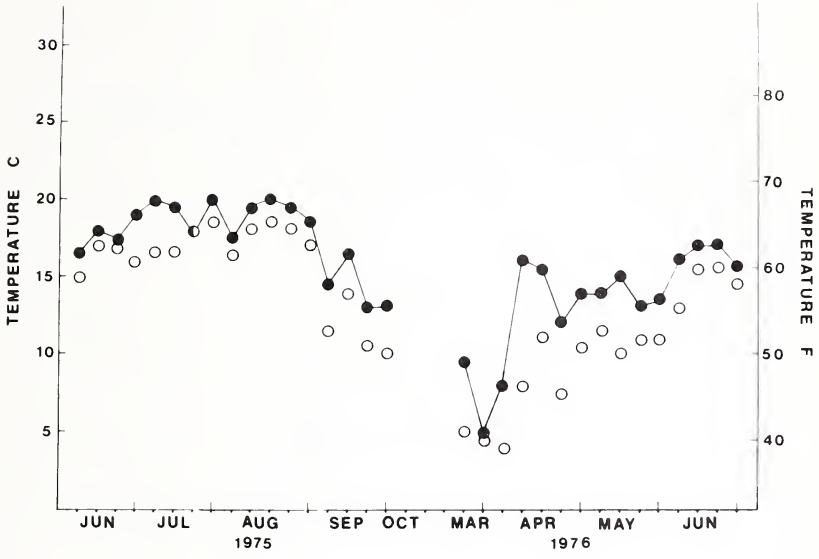

Figure 2. Soil temperature at a depth of 10 cm on the two slopes.

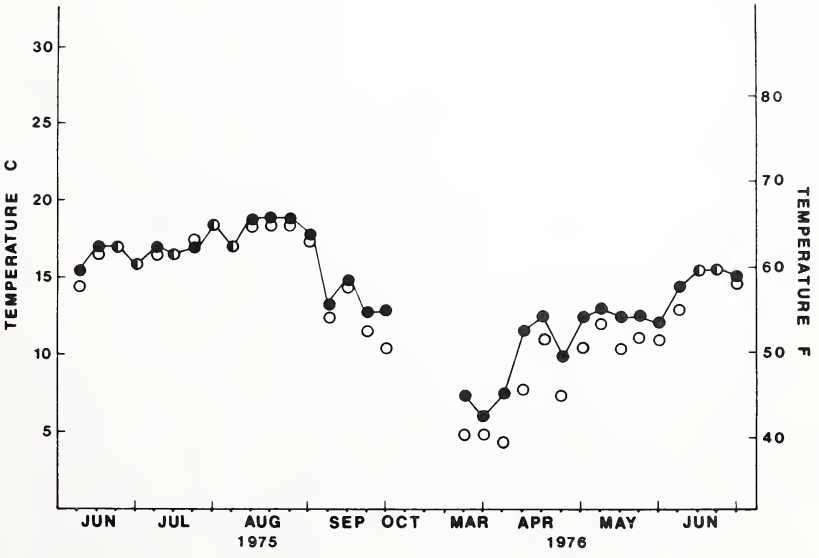

Figure 3. Soil temperature at a depth of 20 cm on the two slopes.

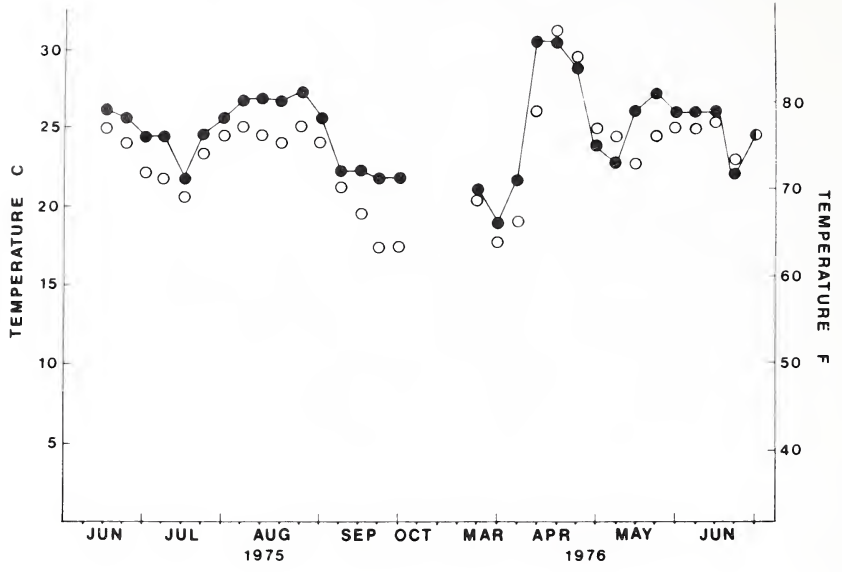

Figure 4. Weekly maximum air temperature at a height of 1 m on adjacent north- (open circles) and south-facing (solid circles) slopes.

was the first date that noticeable leaf expansion on the two slopes was evident. Appreciable differences in soil temperature between the two slopes do not seem to exist at the 20 cm level during the middle portion of the growing season.

Mean weekly maximum air temperatures were 25.2 C for the south slope and 23.9 C for the north slope (Figure 4). During the same period of time, the mean weekly maximum temperature recorded at the U. S. Weather Bureau station at the Mountain Lake Biological Station was 23.9 C. The highest temperatures recorded for the two slopes during the entire study were 30.6 C for the south slope and 31.1 C for the north slope. These temperatures were both recorded for the week of April 16, 1976, well before the initiation of leaf expansion on either of the two slopes. In general, the greatest differences between the two slopes occurred either early in the growing season or near the end. The greatest difference was 4.4 C, which was recorded for the week of April 16, 1976 and for the weeks of Sept. 28 and Oct. 4, 1975.

Mean weekly minimum air temperatures were 6.9 C for the south slope and 6.7 C for the north slope (Figure 5). The U. S. Weather Bureau station mean weekly minimum temperature for the same period of time was 4.4 C. The

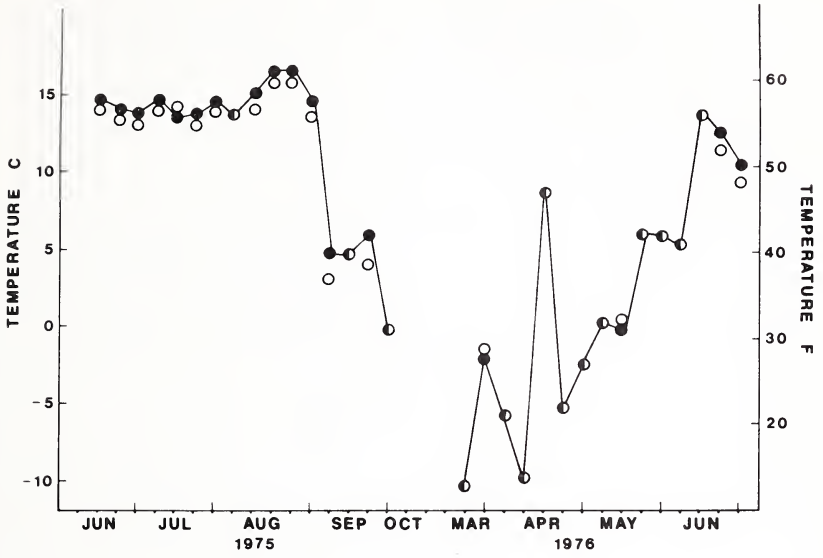

Figure 5. Weekly minimum air temperature at a height of 1 m on the two slopes.

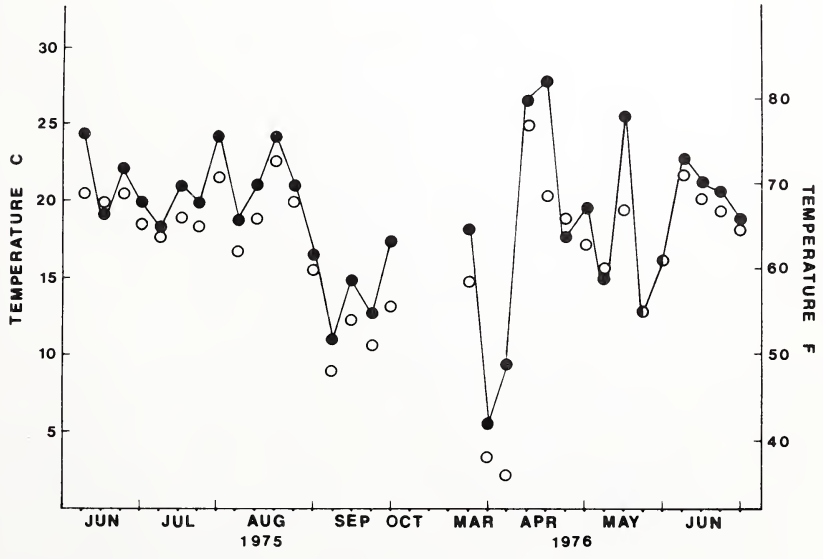

Figure 6. Air temperature in early afternoon at a height of 1 m on the two slopes.

lowest temperature recorded during the entire study was -10.6 C on both slopes for the week of March 26, 1976. The week of May 28, 1976 was the first for which a minimum temperature higher than 0 C was recorded on both slopes. In general, differences in minimum air temperatures between the two slopes were relatively small throughout the entire growing season, and a difference as great as 1.0 C was recorded on only six occasions.

Mean air temperatures on the two slopes, based on measurements taken during the early afternoon when solar radiation is near the daily maximum, were 19.0 C for the south slope and 16.9 C for the north slope (Figure 6). In general, the greatest differences in temperature between the two slopes occurred during the early part of the growing season. The maximum difference was 7.2 C, recorded on both April 9 and April 23, 1976. The smallest differences between the two slopes were recorded within a period from late May to mid-July. A difference in temperature of more than 1.0 C between the two slopes was recorded on only two occasions during the periods of June 14-July 11, 1975 and May 28-July 2, 1976. The minimum difference (0 C) was recorded on May 28, 1976 and June 4, 1976. On one date (June 21, 1975) the temperature on the north slope was higher than that for the south slope.

A fairly close relationship existed between air temperature and the temperature of the soil at the 2 cm level. The mean soil temperature at 2 cm on the north slope (14.9 C) was only 2.0 C lower than the mean air temperature (16.9 C), whereas the mean soil temperature at the same depth on the south slope was only 0.5 C higher than the mean air temperature (19.0 C). The greatest differences between air and soil temperature on both slopes occurred during the first half of the growing season, and no difference greater than 3.5 C was recorded after mid-June on either slope. However, most differences of this magnitude occurred much earlier in the growing season, from late March to early May, and thus before leaf expansion. Differences were generally more pronounced on the north slope, where a maximum difference of 9.0 C was recorded on April 16, 1976. The maximum difference on the south slope (5.4 C) was recorded on June 14, 1975.

Differences in microclimate between adjacent north- and south-facing slopes have been reported in a number of other studies (Shanks and Norris, 1950; Cantlon, 1953; Mowbray and Oosting, 1968). In all of these studies, as was the case in the present study, both air and soil temperatures were found to be generally higher on south-facing than on north-facing slopes. The major contribution of the present study is that it extends the existing knowledge of the nature and magnitude of these phenomena to southwestern Virginia. As such, these data, along with the descriptions and analyses of vegetation and soils also presented in this

paper, are directed toward the objective of determining more precisely the nature of community response to environmental factors.

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Actual date of publication: August 20, 1982

NOTICES

I. At the March 6, 1982 meeting of the Council of the Virginia Academy of Science, the editor was requested to call to the attention of the membership of the Academy the statement of the American Association for the Advancement of Science on the teaching of creationist beliefs in public school science courses. The AAAS statement, adopted by the AAAS Board of Directors and AAS Council in January, 1982, is reproduced below.

AAAS RESOLUTION ON FORCED TEACHING OF CREATIONIST BELIEFS IN PUBLIC SCHOOL SCIENCE EDUCATION

Whereas it is the responsibility of the American Association for the Advancement of Science to preserve the integrity of science, and
Whereas science is a systematic method of investigation based on continuous experimentation, observation, and measurement leading to evolving explanations of natural phenomena, explanations which are continuously open to further testing, and
Whereas the Association respects the right of people to hold diverse beliefs about creation that do not come within the definitions of science, and
Whereas Creationist groups are imposing beliefs disguised as science upon teachers and students to the detriment and distortion of public education in the United States,
Be it resolved that because "Creationist Science" has no scientific validity it should not be taught as science, and further, that the AAAS views legislation requiring "Creationist Science" to be taught in public schools as a real and present threat to the integrity of education and the teaching of science, and
Be it further resolved that the AAAS urges citizens, educational authorities, and legislators to oppose the compulsory inclusion to science education curricula of beliefs that are not amenable to the process of scrutiny, testing, and revision that is indispensable to science.

II. Also at its March meeting of the Virginia Academy of Science Council, it was resolved that all solicitations for donations to the Academy must be cleared with the Fund-Raising Committee before any potential donors are approached. It has proven awkward and embarrassing when industries or other potential donors are approached by more than one representative of the Academy. This needs to be avoided in the future, and clearing all solicitations through the Committee should solve the problem.

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Summer 1982

Survey of the Helminth Parasites of the Rat, *Rattus norvegicus*, from Maymont Park, Richmond, Virginia

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ABSTRACT

Twenty-seven rats, collected at Maymont Park in Richmond, Virginia, were examined for the presence of helminth parasites. Fifteen rats (11 juveniles, 4 adults) were trapped in the fall of 1980 and twelve animals (6 juveniles, 6 adults) were collected in the spring of 1981.

Two species of nematodes, Nippostrongylus brasiliensis (Trichostrongyloidea) and Heterakis spumosa (Heterakoidea) and the cestode Vampirolepis (=Hymenolepis) nana (Hymenolepididae) were found. Each species was highly localized in the digestive tract.

The nematodes were found during both collection periods. Heterakis spumosa had the highest prevalence of infection (85.2%), while N. brasiliensis had the highest mean density ($\bar{X}$=77). Vampirolepus nana was present only in the spring sample. Juvenile rats harbored significantly fewer parasites than the adults. The data indicate a seasonal acquisition for all three species.

The nematodes Capillaria hepatica and Trichinella spiralis were not found.

INTRODUCTION

The rat (Rattus norvegicus L.) is a common pest in urban and rural locations world-wide. Rats harbor a number of species of helminth parasites that can be transmitted to man and other vertebrates (Oldham 1931). The presence of rats, therefore, represents a potential epizootiological problem in zoos and game parks.

A survey of the helminth parasites of rats in Maymont Park (Richmond, Virginia) was undertaken to determine the composition of the helminth fauna. In addition, the potential for transfer of these species to animals maintained in the park for display was assessed.

MATERIALS AND METHODS

Maymont Park is a small zoological park located in southwest Richmond. It was established in 1926 on the grounds of the James Dooley estate. Trapping was conducted in the aviary, a small (20x26x8 m) fenced enclosure. The aviary contains a centrally located pond and an observation platform. Birds housed in the aviary include wild turkeys, wood ducks, black-crowned night herons and white-throated sparrows.

Rats were live trapped during October, 1980 and from March through May, 1981. Traps were baited with a mixture of peanut butter and oatmeal. Raw bacon was occasionally added.

Rats were killed by asphyxiation with chloroform vapors and/or injected with a saturated solution of chloral hydrate. Necropsies were preformed immediately, using standard procedures. Pieces of diaphragm were pressed between glass slides and examined for the presence of Trichinella spiralis larvae.

Nematodes were killed in glacial acetic acid and stored in glycerine alcohol (95 parts 70% ethanol and 5 parts pure glycerine). They were cleared and examined as temporary mounts in lactophenol. Cestodes were placed in saline and refrigerated until they no longer respond to touch. They were then fixed in AFA (alcohol-formalin-acetic acid) and stained in Blachin's stain.

RESULTS AND DISCUSSION

Twenty-seven rats were captured and examined during this study. The majority of animals trapped were juvenile males (Table 1). Males as a group are more active than females and juveniles are more active than adults (Barnett 1975).

This may explain the preponderance of males captured and the high proportion of juveniles in the sample.

Two species of nematodes, Nippostrongylus brasiliensis (Travassos 1914) and Heterakis spumosa (Schneider 1866) were found. A single species of cestode, Vampirolepus (=Hymenolepis) nana (Siebold 1852) was found. Heterakis spumosa had the highest prevalence of infection (85.2%), while N. brasiliensis had the highest mean density ($\bar{X}$=77) (Table 2).

Each species of helminth was found in a distinct part of the gut. Nippostrongylus brasiliensis was wholly or partially embedded in the duodenal mucosa. V. nana was restricted to the ileal region of the small intestine, and H. spumosa was found in the cecum and anterior portion of the large intestine.

Although there appears to be no difference in the prevalence of helminths between adult and juvenile rats, adults have significantly heavier worm burdens for two of the three species of helminths encountered (Table 3). Adult rats forage more widely and ingest a larger quantity of food (Barnett 1975). They would, therefore, have a higher probability of encountering the infective stages of parasitic organisms that are transmitted orally.

Differences in the helminth fauna during the fall and spring collection periods points to a seasonal acquisition for all three species (Table 4). There was no significant difference in mean density during the two collecting periods for N. brasiliensis, due to the wide variation in density of this species in individual hosts. However, of the 12 rats that comprised the spring sample, six were captured during a warm period in mid-March and the remaining animals were captured in late April and early May. None of the animals from the March sample were infected, while all the animals examined in May harbored N. brasiliensis.

Heterakis spumosa demonstrated a similar pattern of acquisition. Although prevalence and mean density were numerically equivalent for both samples (Table 4), all of the rats from the spring collection contained juvenile stages of H. spumosa. Few juvenile worms were found in the fall collection.

Vampirolepus nana was not found in the fall sample, but was present in

Table 1. Summary of sex and age of rats trapped at Maymont Park

	Fall, 1980		Spring, 1981	
	Male	Female	Male	Female
Adults	5	0	5	1
Juveniles	10	0	5	1
Total	15	0	10	2

Table 2. Summary of the helminth parasites in rats at Maymont Park 1980-1981

	% Prevalence	$\bar{X}$ Density ± S.D.	Range
Nematodes			
Nippostrongylus brasiliensis	63	77 ± 152	1-487
Heterakis spumosa	85.2	37.4 ± 40.3	1-174
Cestode			
Vampirolepis nana	18.5	47 ± 63.6	1-156

Table 3. A comparison of the helminth parasites of rats at Maymont Park according to host age

	Juveniles (n=16)		Adults (n=11)	
Nematodes	% Prevalence	$\bar{X}$ Density	% Prevalence	$\bar{X}$ Density
Nippostrongylus brasilinsis	68.8	9.9 ± 10.9*	63.6	172 ± 209*
Heterakis spumosa	81.3	21.2 ± 18**	58.5	59 ± 51.7**
Cestode				
Vampirolepis nana	6.3	1 ± 0	36.4	59 ± 66.6

* $p < 0.05$ Wilcoxson's Sign Rank Test

** $p < 0.025$

Table 4. A comaprison of the seasonal occurrence of the helminth parasites of rats at Maymont Park

	Fall (n=15)		Spring (n=12)	
Nematodes	% Prevalence	$\bar{X}$ Density	% Prevalence	$\bar{X}$ Density
Nippostrongylus brasiliensis	80	103 + 176.3	50	12.3 + 8.2
Heterakis spumosa	80	36 + 47.3	91.7	39.1+ 33.3
Cestode				
Vampirolepis nana	0	0	41.7	47 + 63.2

41.7% (5/12) of the rats examined in the spring. This cestode is short lived in the definitive host (Shorb 1933) with a patent period of 11-16 days. The life cycle of *V. nana* may be completed directly, via the ingestion of eggs, or the eggs may be ingested by an arthropod, which serves as the intermediate host, and develop to the cysticercoid stage which is a more typical pattern for hymenolepidid cestodes. In view of the low resistance of the eggs of *V. nana* to dessication and low temperatures (Shorb 1933), this may provide a mechanism for overwintering in temperate regions.

The three species found in the current study are typical components of the parasite fauna of *Rattus norvegicus* (e.g., Oldham 1931, Luttermoser 1936) as well as other species of *Rattus* (e.g., Oldham 1931, Yokagawa 1920). *Nippostrongylus brasiliensis* and *Heterakis spumosa* are principally parasites of members of the family Muridae (old world rodents) and have not been reported from organisms other than rodents. Therefore, they pose no threat to other animals maintained at the park. *Vampirolepis nana* has been reported from a variety of species of rodents (Yamaguti 1959), muskrats (Lavroff 1957) as well as man. There is some support for recognizing two varieties of *V. nana*, var. *fraterna* in rodents and var. *nana* in man (Wardle and McLeod 1952). This is based on reduced infectivity of the larval forms of the rodent variety for humans and the human variety for rodents, although cross transmission can occur. Thus, there is a possibility of transfer of this species to muskrats and perhaps beaver maintained at Maymont as

well as the possibility of transfer to humans, particularly the staff who are involved in feeding and maintenance of the animals and the facilities.

None of the rats harbored infections of Capillaria hepatica or Trichinella spiralis which are known to be pathogenic in a variety of hosts including man. Holliman and Meade (1980) reported Trichinella spiralis from a variety of rodents in Henrico County, 14 km from Richmond.

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The authors wish to thank Mr. Fred Murray, Curator of Animals at Maymont for permitting access to the park and Mr. Robert Deane for assistance in trapping.

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Changes in Balance and Hand-eye Coordination in Educable Mentally Retarded Adults as a Result of an Eight-week Swimming Program

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ABSTRACT

Ten Educable Mentally Retarded (EMR) persons were administered performance tests on the stabilometer and Shape-O-Ball before and after an eight-week swim program. The swim program was conducted two times per week for one hour each session. It was the purpose of this investigation to determine if swimming had an effect on the balance and/or hand-eye coordination of EMR persons. Tests included time on the balance board (TOB); time off balance (OFFBAL); and time to complete the Shape-O-Ball Task (TTC). Using least squares analyses, the results showed that for the variable OFFBAL, the difference between trials was not significant ($P>.05$); between sexes was significant ($P<.01$) and that sex*trial was also significant ($P<.01$). For the variable TOB, the differences between trials, sex, and their interaction were not significant ($P>.05$). For the variable TTC, the effects of trial and of sex were both significant ($P>.05$), while that for trial*sex was not ($P>.05$). The results indicate that swimming may be related to an improvement in hand-eye coordination of EMR persons.

INTRODUCTION

Most research on the effects of physical and/or motor training programs for the mentally retarded has focused on educable mentally retarded (EMR) children, whose chronological ages were 8-15 years. It is well documented that programs of physical activity improve children's physical fitness parameters (Adams, 1970; Chasey & Wric, 1971; Courtney, 1972; Funk, 1971; Moran, 1971; Hayden, 1969; Ross, 1969). It has also been known that they have the capacity to develop these skills on a level approaching their normal peers (Hayden, 1969; Howe, 1959). Yet, their initial levels of physical fitness are often inferior to those of normal children (Rarick, et al., 1970; Stein, 1963). The development of physical activity programs for somewhat older EMR persons, therefore, is of critical importance to the retarded, not only for reasons of health, but to develop the stamina needed to sustain moderate activity levels through a normal working day.

This report is to present data on the effects of swimming on balance and hand-eye coordination among ten young EMR adults after an eight-week swim program.

METHODOLOGY

The program was conducted jointly by two organizations: (1) the Department of Health, Physical Education and Recreation at Virginia Tech and (2) the New River Valley Association for Retarded Citizens (NRVARC).

The swimming activities and the attendant experimental observations that comprise this investigation were conducted on Monday and Wednesday evenings from 6-7 PM for eight consecutive weeks, beginning in March, 1979. It was concurrent with a similar learn-to-swim program for the non-retarded.

Data for this report were taken from ten EMR persons enrolled in special education classes or in the local sheltered workshop. Each lived within a 35-mile radius of Virginia Tech. The mean age of the subjects was 18.6 $\pm$ 3.3 years.

Prior to the start of the program, pre-tests were administered to the subjects in the pool area. Tasks included the stabilometer and the Shape-O-Ball. The stabilometer was a balance board to which automatic devices were attached that: (1) recorded the number of times the balance board touched the ground, signifying the subject was off balance, later called OFFBAL, and (2) the net time in a 20-sec interval that the subject kept the board in a balanced state, later called Time-On-Balance (TOB). Three 20-second trials on the stabilometer were conducted with each subject. The Shape-O-Ball (Tupperware Products) is a plastic ball from which 10 geometric shapes are cut from the hull (i.e., triangle, square, etc.). The subject was required to insert a plastic geometric piece into its correct location on the hull of the ball, thus measuring hand-eye coordination. Three trials were administered on the Shape-O-Ball and data were collected on Time-To-Completion (TTC), or the time required to place all the pieces in the Shape-O-Ball. Prior to the pre-test, each subject was permitted practice trials to reduce the possibility of habituation.

The swimming program lasted eight weeks. Instructors were college-age students enrolled in either Water Safety, Therapeutic Recreation, or Adapted Physical Education classes. Instruction was administered according to procedures outlined by the American National Red Cross for the beginning through intermediate categories. A post-test was administered on the same traits after the eight-week program.

Table 1

Mean values for OFFBAL, TOB, TTC by sex and time, pre and post.

	Stabilometer						Shape-O-Ball		
	OFFBAL[a/]			TOB[b/]			TTC[c/]		
Sex	Pre	Post	Ave.	Pre	Post	Ave.	Pre	Post	Ave.
M	15.6	18.0	16.8	8.2	8.4	8.3	75.9	50.1	63.0
F	23.6	19.6	21.6	7.2	7.7	7.4	81.7	60.3	71.0
AVE	19.6	18.8	19.2	7.7	8.0	7.8	78.8	55.2	67.0

a/ OFFBAL, number of times the stabilometer was off balance in a 20-second trial.

b/ TOB, time on balance, in seconds.

c/ TTC, time to completion, seconds. See text for details.

Data reported are averages of three observations per trial, classified by subject, sex, and trial. The SAS package of statisitical programs (Barr 1976) was used to complete least squares analyses (Snedecor & Cochran, 1967). This enabled comparison of the relative importance of the main effects and certain interactions.

Table 2

Least Squares Analyses for OFFBAL, TOB, and TTC

			OFFBAL		TOB		TTC	
Source		df	M.S.	P F	M.S.	P F	M.S.	P F
Model	11		81.85	.0001	7.04	.0011	1096.13	.0025
Trial		1	4.82	.58	1.368	.41	2088.60	.017
Sex		1	277.35	.0001	2.481	.27	1440.60	.046
T*S		1	156.82	.0026	.308	.69	147.27	.515
Subject/Sex		8	65.93	.0007	9.16	.0003	1047.73	.007
Error	48		15.59		1.98		341.94	
TOTAL	59							

RESULTS AND DISCUSSION

In Table 1 are presented means by time (pre and post) and sex. Results from the supporting least squares analyses are shown in Table 2. The results indicate that for the variable called OFFBAL, the difference between trials, 19.6 vs 18.6, was not significant ($P>.05$); that between sexes, 16.8 for males vs 21.6 for females, was significant ($P<.01$); and the trial*sex interaction was also significant ($P<.01$). In the latter case, scores for males increased from 15.6 to 18.0 during the eight-week program, while those for females decreased from 23.6 to 19.6.

For the variable TOB, differences between trials, between sexes and among the trial by sex subclasses were not significant ($P>.05$).

For the variable TTC, the effects of trial and of sex were both significant ($P<.05$), while that for trial*sex was not significant ($P>.05$). This means that the "average" effect for either main factor was not dependent on the level of the other factor for which an estimate is desired.

The results from the test criterion, TTC, require little interpretation. They show a reduction of 23.6 seconds, or about 30%, in time required to complete the Shape-O-Ball task from the beginning of the eight-week program until its completion. In part, this improvement in problem solving ability and hand-eye coordination was a direct result of the swimming activity. The statistical significance of these results easily generates a sense of optimism about the program. But with the small number of subjects on which this report is based, the work clearly needs repetition and refinement.

Toward this end, the program has been continued since its inception and expanded to include approximately 30 subejcts.

The present study was an attempt to quantify changes in specific motor-performance skills of the handicapped as a result of participation in an aquatics program.

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Cytotoddia (=*Toddia*) Infection of Serpentes and Its Incidence in Two Geographical Areas

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ABSTRACT

An intraerythrocytic parasite resembling virus particles, referred to by the non-specific name, cytotoddia, and synonymous with conditions for which the generic name Toddia was proposed was observed in some Serpentes species in the lab and its incidence surveyed in two different geographical areas. Cytotoddia was discovered for the first time in Virginia (5.6% infection rate) and the highest infection rate yet reported (25%) was found on Garden Island, Michigan.

Transovarian transmission of cytotoddia was searched for in neonates of captured specimens and cytotoddia was found not to be transmitted to the young of naturally infected females.

To test low temperature as a possible environmental trigger for previously reported remission of cytotoddia in the winter with a subsequent relapse in the spring in infected snakes, a cold suppression experiment was conducted. The only apparent result of the experiment was a decrease in the percentage of infected circulating blood cells, and no evidence of a remission with a subsequent relapse was found.

INTRODUCTION

Intracorpuscular blood parasites of various reptiles and other vertebrates have, in the past, been assigned to the protozoan Class Sporozoa. The exact taxonomic position of a number of described species of blood parasites found in poikilotherms is obscure (Wenyon, 1926; Pierce and Castlemen, 1974). Infections in question include Cytamoeba Labbe, 1894, Toddia Franca, 1911, Pirhemocyton Chatton and Blanc, 1914, Bertarellia Carini, 1930, Immanoplasm Neumann, 1909, and Haematractidium Henry, 1910. More recent investigations of infections such as these are leading to new evaluations of the taxonomic status and true identities of these apparent protozoan parasites (Johnston, 1975).

The genus Toddia was erected for what appeared to be an organism found within the erythrocytes of the toad, Bufo regularis, from Guinea, Africa (Franca, 1911). The parasite was described as a round, reddish staining mass, 0.8 to 3.5 μm diameter. Associated with it were rectangular, crystal-like

bodies. Previously, Dutton et al. (1907) described "an unidentified parasite" in similar terms except their parasite measured from 1.5 to 5.5 μm and had blue-green, crystal-like bodies associated with it. Both the crystals and the red masses were present in varying numbers. Because there was evident bluish cytoplasm surrounding the red masses, the organism was considered to be a protozoan. Yongue (1964) reported this apparent organism in Natrix sipedon in Michigan. He subsequently referred to it as a condition, rather than a parasite, and called it by the non-specific name cytotoddia (Yongue, 1966) because round red-staining masses were present within the cytoplasm; Toddia-like because inclusion bodies resembling crystal-like masses were associated with the red-staining masses. This description of cytotoddia was indistinguishable from other accounts of Toddia in the literature (Figure 1). Toddia has been recorded from nine species of snakes (Johnston, 1975; Yongue, 1964; Marquardt and Yeager, 1967; Pessoa, 1967, as cited in Johnston, 1975; Sousa and Pessoa, 1973, as cited in Johnston, 1975); from six species of Amphibia (Franca, 1911; Scorza and Boyer, 1956, as cited in Marquardt and Yeager, 1967, 1967; Pereira et al., 1973; and Miyata and Miyagi, 1977); from one species of fish (Arcay de Peraza and McLure, 1971); and from one species of lizard (Arcay de Peraza et al., 1971). The inclusions ranged in shape from hexagonal, triangular, rhomboidal, trapezoidal, octagonal, to square. The inclusions were found in the cytoplasm and/or in the nucleus (Arcay de Peraza and McLure, 1971). Cytochemistry, organism development, and pathogenic studies of Toddia were conducted by Pereira et al., (1972, 1973). They concluded that more research was needed to establish a viral nature for Toddia. In a subsequent electron microscope study, the probable viral nature of Toddia was proposed (De Sousa and Weigl, 1975b). Yongue and Booker (1979) using ultrafiltration and electron microscopy, also demonstrated that Toddia was not a protozoan and the host cell cytoplasm contained viral-like particles. No vectors of Toddia have been established. Two other apparent protozoans, V.E.N. (Viral Erythrocytic Neurosis, formerly called P.E.N., Piscine Erythrocytic Necrosis) and Cytamoeba have also been demonstrated to be smaller than any known protozoan. V.E.N. has been shown to be a virus (Evelyn and Traxler, 1978) and Cytamoeba is considered to be related to such bacteria as Chlamydia and Rickettsia (De Sousa and Weigl, 1975a).

This report deals with two laboratory experiments concerned with cytotoddia (=Toddia) transmission and relapse, and two surveys to check for the incidence of this infection in two separate geographical areas.

Materials and Methods

Transmission and Relapse of Cytotoddia

Snake specimens collected in Michigan and Virginia were held in the laboratory, maintained at room temperature and were fed live meals. Blood samples were obtained by tail snip, and duplicate smears were air dried, fixed in absolute methanol, and stained in 10% buffered Giemsa stain.

Snakes used in experimental infections were considered free of infection if no evidence of cytotoddia was seen after scanning at least 40% of a stained blood smear under oil immersion.

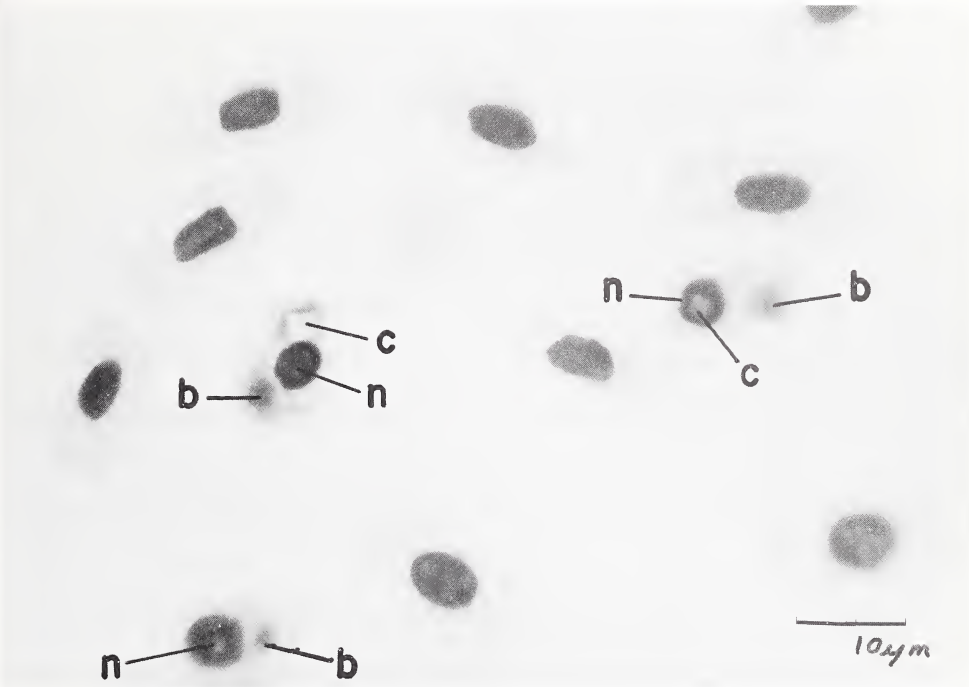

Figure 1. Infected erythrocytes with basophilic masses (b) and/or crystalline masses (c) which may be present within the cytoplasm and/or within the nucleus (n).

Mechanical transmissions of cytotoddia via intraperitoneal injection of blood from infected hosts to uninfected specimens were attempted. Ten drops of blood from a donor tail snip were collected in 20 ml. of 0.65% reptilian saline and an aliquot of 0.5 ml of this blood preparation was injected into the recipient intraperitoneally with a 26 gauge 3/8 inch intradermal needle.

The recipient snakes were bled at inoculation and twice a week beginning one week after inoculation to check for infection. Evidence of cytotoddia was considered to be the presence of a blue-purple or reddish basophilic staining mass as well as the presence of an intraerythrocytic crystalline mass (Figure 1). The recipient snakes were considered uninfected if no evidence of cytotoddia was seen after 1 to 1 1/2 months.

(a) Cold Suppression of Cytotoddia

Remission of cytotoddia occurs with a degree of regularity in the laboratory in the winter but only rarely with a subsequent relapse in the spring in infected snakes and this was reported by Yongue (1966a). To look for indications that the remission and relapse were temperature triggered, three Natrix sipedon were refrigerated. One of the specimens had a natural infection of cytotoddia (N-12), the other two had mechanical infections (N-6, N-8). These snakes were bled, fed two fish each and placed in a refrigerator. The temperatures were

gradually lowered from 25°C to 5°C over a seven day period. The snakes were kept in the dark at 5°C for fifty-seven days. The temperature was then gradually raised to 25°C over a seven day period and the snakes were removed from the refrigerator and bled. A mechanically infected N. sipedon was maintained at room temperature and used as a "control" specimen.

(b) Transovarian Transmission of Cytotoddia

Because water snakes are ovoviviparous, it was possible to check for transovarian transmission of cytotoddia to the young of infected gravid females. Eight gravid Natrix sipedon of the experimental group gave birth during the course of this study. Young from six of the eight litters born in the lab were checked, and a litter of neonate Natrix fasciata from the Dismal Swamp in Virginia was also checked.

(c) Surveys

(1) On the southwestern side and southern end of Garden Island, Michigan, 100 Natrix sipedon, 19 Thamnophis sirtalis and 4 Diadophis punctatus were captured and bled once to survey for incidence of infection. These slides were fixed in absolute methanol and brought back to the lab for staining and study.

(2) In southwest Virginia within a 25 mile radius of Blacksburg, 36 Natrix sipedon and 14 Natrix septemvittata were collected and sampled over a four month period for the incidence of infection.

The original intent of these surveys was to sample for cytotoddia in N. sipedon only. The few Thamnophis, Diadophis, and Natrix septemvittata which were sampled were also present in the collection areas and offered the potential for more information on cytotoddia and its incidence.

RESULTS

(a) Cold Suppression of Cytotoddia

The results of this experiment are given in Table 1. These refrigerated snakes showed a decrease in the percentage of infected cells. None of the three snakes exhibited a complete remission or a subsequent relapse of cytotoddia when returned to room temperature.

(b) Transovarian Transmission of Cytotoddia

Table 2 shows the results of these observations. Four of the six gravid N. sipedon, who gave birth in this study, had natural infections of cytotoddia. The blood profile of the gravid N. fasciata from the Dismal Swamp was unknown. At least half of the young from all the litters were sampled for cytotoddia and none of the neonates exhibited the infection.

(c) Surveys

The results of the surveys in Michigan and southwest Virginia are presented in Table 3. Twenty-five (25%) N. sipedon on Garden Island in Michigan and two (5.6%) N. sipedon from southwest Virginia were found to be naturally infected. No Thamnophis, Diadophis, or N. septemvittata exhibited cytotoddia.

DISCUSSION

In the cold suppression experiment (Table 1) there was no evidence of a remission with a subsequent relapse. The only apparent result of the cold treatment was a decrease in the percentage of infected cells. Since relapse had occurred only rarely in the laboratory, it was thought that the relatively constant laboratory warmth might be a factor. Additionally, we had been constantly asked what happens if the snakes are allowed to "hibernate"? Thus, the decision to perform this experiment was made. Yongue (1965, 1979) noted remission in winter with, on rare occasion, a subsequent relapse in spring in snakes held at room temperature, but none of the infected snakes in this study exhibited this phenomenon. Why no remission or subsequent relapse occurred in this case is unknown.

There was no evidence of transovarian transmission of cytotoddia (Table 2). Members of the genus Natrix are ovoviviparous and are closely related to the genus Thamnophis which possess a relatively simple chorio-allantoic placenta where fetal and maternal capillaries are closely opposed (Hoffman, 1970). This is the site for gaseous exchange and perhaps the transfer of haemotrophic materials in Thamnophis Hoffman (1970). Transovarian transmission is unknown to occur in the parasitic nematode Heterakis gallinarum when it passes the protozoan, Histomonas meleagrides (causing black head disease), to birds via its eggs as reported by Schmidt and Roberts (1977). Transplacental transmission of viruses such as Rubella, Cytomegalovirus, Herpes Simplex II, Poliovirus, and possibly leukoviruses was reported by Acton et al. (1974); transplacental transmissions of Treponema pallidum (Myrvik et al., 1974) and

Table 1. Percent cells infected during cold treatment experiment. Snake naturally infected with cytotoddia (N-12) and mechanically infected snakes (N4, N8 and "control".

Snake	Day 1	Following Treatment Day 71	Day 82	Day 108
Cold Treated				
N-4	3.2%	1.4%	.07%	.02%
N-8	2.1%	.06%	.04%	.03%
N-12	11.9%	3.7%	3.6%	3.0%
Room Temp.				
Control	1.6%	1.7%	1.5%	1.6%

Table 2. Neonates from infected females checked for cytotoddia.

Gravid Females	Capture Location	Cytotoddia in Females	Number of Young Liveborn	Number of Young Sampled	Young with Cytotoddia
Natrix sipedon (N-5)	Beaver Island, Mich.	+	10	5	-
Natrix sipedon (N-7)	Beaver Island, Mich.	+	8	5	-
Natrix sipedon (N-9)	Beaver Island, Mich.	+	9	5	-
Natrix sipedon (N-22)	Garden Island, Mich.	+	15	11	-
Natrix sipedon (N-25)	Garden Island, Mich.	-	27	17	-
Natrix sipedon (N-27)	Garden Island, Mich.	-	14	9	-
Natrix fasciata	Dismal Swamp, Virginia Beach, Va.	?	7	5	-

Table 3. The incidence of cytotoddia on Garden Island, Michigan and within a 25 mile radius of Blacksburg, Virginia.

Species	Area	Sample Size	Infected Snakes
Natrix sipedon	Garden Island, Michigan	100	25(25%)
Natrix sipedon	Southwest Virginia	36	2(5.6%)
Thamnophis sirtalis	Garden Island, Michigan	19	0
Diadophis punctatus	Garden Island, Michigan	4	0
Natrix septemvittata	Southwest Virginia	14	0

the nematode worm, Trichinella spiralis (Meade, 1977) are also documented. Although transplacental transmission does occur it is evident that cytotoddia failed to cross the simple placenta in these infected female Natrix.

The results of the surveys from southwest Virginia and Garden Island, Michigan, are presented in Table 3. The 25% infection of Michigan snakes with cytotoddia is higher than any other study reported in the literature. For example, Yongue (1965) reported 5.8% in Natrix sipedon in Michigan, Marquardt and Yeager (1967) reported 2.4% in Agkistrodon piscivorous leucostoma in Louisiana, and <1% of all anurans from the Malayan Penninsula had cytotoddia (Sullivan and Sullivan, 1977). The cause of the high infection rate on Garden Island, Michigan is unknown.

The 5.6% infection rate found in Natrix sipedon from Virginia approximated other reported studies. This is the first report that cytotoddia has been found in Virginia and the first time it has been seen in this species other than in Northern Michigan.

There has been no study on a possible vector for cytotoddia. If there is a vector, one might reason that cytotoddia was not found in all areas in this study because of a microhabitat requirement of the vector. Telford (1977) said that spotty distribution of saurian malaria reflects the absence of critical microhabitat requirements for vectors rather than a limited dispersal capacity of vertebrate hosts.

Additionally, if a vector is involved in cytotoddia transmission this could be the reason for the infection being found only at Mill Creek in the Virginia Survey. Ball (1967) said that the distribution of blood sporozoan infections in reptiles does not correspond with the range of the hosts. A probable explanation is that the controlling factor is the range of the vector.

If a vector is involved in cytotoddia transfer then possibly an ideal habitat exists for the vector on Garden Island and it is able to infect large numbers of N. sipedon.

Another possible factor in incidence of the infection could be host behavior. McAuliffe (1977) noted this with regard to the interspecific host variation in hemogregarine parasitemia; basking behavior of turtles accounted for the interspecific variation in hemogregarine parasitemia and was not an intrinsic factor within the host. McCosker (1926) noted that fighting between Blennoid fishes brought about transmission of lymphocystis disease. Another possibility is that transmission could be through a food source: Ayala (1971) reported that transmission of Plasmodium via ingestion of infective sandflies by fence lizards.

The infectious agent of cytotoddia (=Toddia) has been suggested to belong to the icosahedral cytoplasmid deoxyriboviruses (I.C.D.V.) group by De Sousa and Weigl (1975b). Also placed in this group are Pirhemocyton (Stehbens and Johnston, 1966), iridescent viruses, lymphocystis virus, and others (Kelly and Robertson, 1973). Daly et al. (1980) found virus-like particles associated with Pirhemocyton inclusion bodies in erythrocytes of the yellow belly water snake and placed it in a different group from Stehbens and Johnston (1966). They said that their Pirhemocyton inclusion bodies resembled Type-A and Type-C virions of the oncornavirus group in both morphology and size when viewed with electron microscopy. The true ultrastructure of Pirhemocyton inclusion bodies as well as the infectious agent of cytotoddia (=Toddia) and similar infections need a great deal more research before discrepancies can be resolved and satisfactory classification systems developed, and work is being continued.

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Time Series Forecasting: A Description and Explanation of A Method and Approach

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This will describe a method and approach which may be used by business planning groups in quantitatively evaluating historic data (time series) for use in forecasting. This analysis structure is based upon generally accepted applied mathematical techniques and should assist the business planner in improving the accuracy of forecasts, particularly in the areas of industry and commodity studies.

General

Original data (that which depicts the past for any time series) may be affected by one or more of the following influences, each of which should be considered when using any past data to forecast:

Secular Trend (T)

This term applies to the general movement of data over long periods of time (generally years). It is the long-term increase or decrease which the time series appears to exhibit in the form of continuous growth, stagnation or decline. An example is the growth in U.S. population between 1900 and 1980 which has reflected an increasing secular trend over the period. Often, secular trends can be mathematically defined and used to forecast the future of the series.

Seasonal (S)

These variations, when present, are periods (months or quarters) of high or low activity, relative to the general trend of the series, which recur during each year. Since seasonal variations generally exhibit a predictable pattern, these influences can be isolated for quantitative evaluation and description. Climate changes, customs and practices are several of the causes which create seasonal variations in data. An example is the increase in gasoline sales which usually results during the summer months and holidays when consumers increase their use of automobiles for recreational purposes.

Cyclical (C)

Cyclical fluctuations may be recognized by periods of high or low activity, around the secular trend, which persist for two or more years. This type of variation has been recognized in many time series associated with the U.S. economy, most notably the business cycle with its various phases, e.g., recession, recovery, etc.

While any analysis of time-series movements should include an examination of underlying cyclical movements, these patterns often lack conformity over time and are difficult to predict with accuracy.

Random (R)

Random or irregular variations may be present in any time-series. Characteristically, they persist for limited intervals of time and tend to occur above the secular trend as often as below, thus cancelling out.

Since a time-series may be affected by one or more of the above factors, we may describe the composition of any series by the following relation:

O = T x C x S x R where: O = original data
T = secular trend
C = cyclical fluctuations
S = seasonal variations
R = random disturbances

This mathematical relation is significant as it provides a framework for "decomposing" time-series data into the four major elements of variations. For example, to eliminate the secular trend from the data to be studied, we would remove the "T" from the equation as follows:

$$S \times C \times R = (T \times S \times C \times R)/T$$

Seasonal variations and secular trend may be eliminated in a similar manner:

$$C \times R = (T \times S \times C \times R) / (T \times S)$$

This would leave only the variations associated with cyclical fluctuations and random disturbances (the two elements which often are unpredictable) for review and evaluation.

It should be recognized that numerous mathematical methods exist for decomposing time-series. Generally, a direct relation exists between the complexity of the mathematical approach selected and the accuracy of forecast results. However, it follows that as computation complexity increases, the manpower required to accomplish the analysis increases proportionately (Note: Forecast related computations often may be expedited through the use of company computer libraries which contain standard statistical support programs).

To achieve a reasonable balance between forecast accuracy and available manpower, the techniques and structure which follow provide an efficient method and approach for business planners in decomposing and forecasting time-series.

Method and Approach

Initial Considerations

In addition to being pertinent, several other factors should be considered in selecting data to be used as a basis for forecasting.

If the forecast requires that future expectations be expressed in terms of months or quarters, a time series of not less than 30 to 40 data points generally is viewed as a practical minimum. To reduce computations (and increase the likelihood of forecasting accuracy), quarterly data may be preferred over monthly.

However, if a forecast by month is essential, it is necessary to determine if the series may be affected by the number of calendar or working days which occur in each month. For example, if the series describes a level (prices, inventories, etc.), days per month usually are not a factor. Conversely, sales and production data, for example, represent sums or totals accumulated during each month and these figures often require restatement to a "volume per day" basis. This is accomplished simply by dividing the actual "monthly volume" by the actual number of days (calendar or work, as appropriate) in the month. Next, if monthly volumes (rather than daily) are required, multiply the "volume per day" figures by a constant, such as, 21 for workweeks which have 5 days. This will express all monthly data on an equivalent basis so that variations due to calendar or workdays are eliminated.

Approach

Employing the mathematical relation previously identified, i.e. O = T x C x S x R, business planning groups may decompose and forecast a time series as follows:

Action	Method
Eliminate Random and Seasonal influences (monthly & quarterly data only)	Moving Averages; Ratios to Moving Averages; Adjusted Means
Identify Secular Trends	Least Squares and Regression Equations; Descriptive Statistics
Isolate Cyclical Influences	Relative Residual Method
Forecast Time Series	Least Squares and Regression Equations, adjusted for Seasonal and Cyclical Influences (as necessary).

To illustrate the evaluation process for each of the above methods, data representing demand, expressed in millions of tons (whenever the word 'tons' appears, millions of tons are implied),for a fictional commodity will be employed.

Eliminate Random and Seasonal Influences

As a first step, the time series should be plotted on arithmetic paper. This allows for an early determination of the general sweep of the data and its continuity.

In our example, the time series to be evaluated appears under the caption entitled "Demand" on Schedule 1 and has been graphically represented on the upper left portion of Chart 1.

Next, moving totals are computed for the entire series. As shown on Schedule 1, the first three moving totals were derived as follows:

Year	Quarter	Demand	Moving Total
1	1	12	
	2	11	
	3	11	44
	4	10	41
		44	
2	1	+ 9	38
		53	
1	1	- 12	
		41	
2	2	+ 8	
		49	
1	2	- 11	
		38	

Since quarterly data is being used, each moving total is divided by 4 to determine the moving average for that quarter.

To complete Schedule 1, the ratio of actual demand to each moving average is computed (demand/moving average).

All ratios then are aligned by quarter as shown on Schedule 2. Next, the high and low ratios under each quarter are eliminated which allows remaining ratios to be totaled for each quarter. These totals are divided by their frequency which results in an adjusted mean by quarter.

If the four adjusted means total to 400 (1200 in the case of monthly data), the means represent the seasonal adjustment index or factors we are seeking. In this example, the sum of the adjusted means is 402.5. Therefore, it is necessary to adjust the seasonal index to total 400. The process, termed "leveling the index", is accomplished as follows:

1. Divide 400 by the sum of the adjusted means...the resulting factor is .9937888.

2. Multiply each of the adjusted means by the factor to derive the seasonal index for each quarter. Each factor then should be plotted as on the lower left of Chart 1. This allows for visual analysis of seasonal patterns and variations.

TIME SERIES EXAMPLE
DESEASONALIZATION OF ACTUALS

Schedule 1

Year	Quarter	Demand (MM Tons)	Moving Total	Moving Average (Uncentered)	Ratio to Moving Average
1	1	12			
	2	11			
	3	11	44	11.0	100.0
	4	10	41	10.3	97.1
2	1	9	38	9.5	94.7
	2	8	36	9.0	88.9
	3	9	36	9.0	100.0
	4	10	38	9.5	105.3
3	1	11	42	10.5	104.8
	2	12	46	11.5	104.3
	3	13	50	12.5	104.0
	4	14	54	13.5	103.7
4	1	15	56	14.0	107.1
	2	14	56	14.0	100.0
	3	13	54	13.5	96.3
	4	12	50	12.5	96.0
5	1	11	46	11.5	95.7
	2	10	44	11.0	90.9
	3	11	44	11.0	100.0
	4	12	46	11.5	104.3
6	1	13	50	12.5	104.0
	2	14	54	13.5	103.7
	3	15	58	14.5	103.4
	4	16	62	15.5	103.2
7	1	17	64	16.0	106.3
	2	16	64	16.0	100.0
	3	15	62	15.5	96.8
	4	14	58	14.5	96.6
8	1	13	54	13.5	96.3
	2	12	52	13.0	92.3
	3	13	52	13.0	100.0
	4	14	54	13.5	103.7
9	1	15	58	14.5	103.4
	2	16	62	15.5	103.2
	3	17	66	16.5	103.0
	4	18	70	17.5	102.9
10	1	19	72	18.0	105.6
	2	18	72	18.0	100.0
	3	17	70	17.5	97.1
	4	16			

Schedule 2

TIME SERIES EXAMPLE
DESEASONALIZATION OF ACTUALS

Year	RATIOS TO MOVING AVERAGES: 1st Qtr.	2nd Qtr.	3rd Qtr.	4th Qtr.
1	-	-	100.0	97.1
2	94.7*	88.9*	100.0	105.3*
3	104.8	104.3*	96.3*	103.7
4	107.1*	100.0	104.0*	96.0*
5	95.7	90.9	100.0	104.3
6	104.0	103.7	103.4	103.2
7	106.3	100.0	96.8	96.6
8	96.3	92.3	100.0	103.7
9	103.4	103.2	103.0	102.9
10	105.6	100.0	97.1	-
Total	716.1	690.1	800.3	711.5
Frequency	7	7	8	7
Adjusted Mean	102.3	98.6	100.0	101.6
Index(Leveled @ .9937888)	101.7	98.0	99.4	101.0

*High/Low Ratios Eliminated.

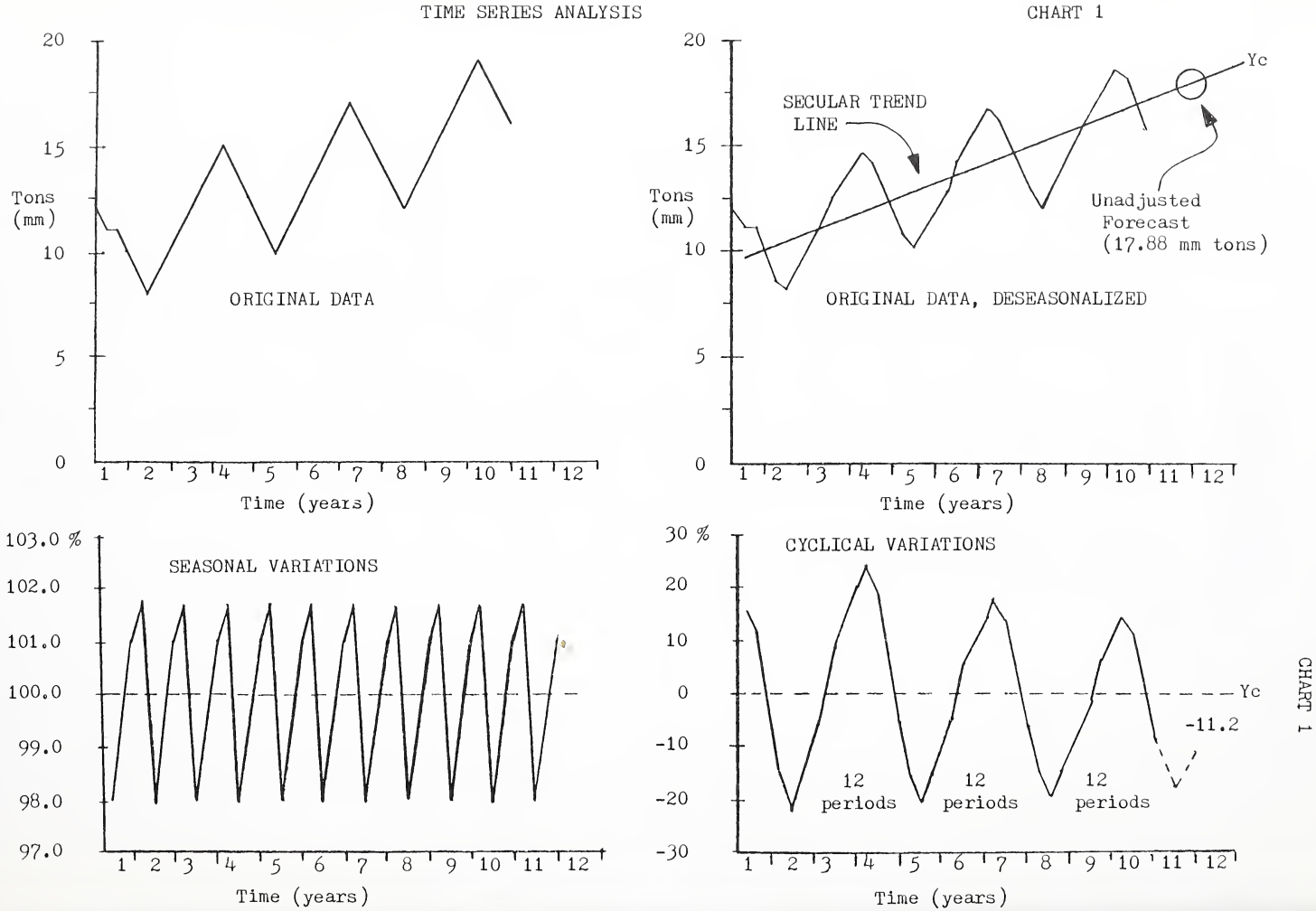

TIME SERIES ANALYSIS
CHART 1
Tons (mm)
ORIGINAL DATA
Time (years)
SECULAR TREND LINE
Yc
Unadjusted Forecast (17.88 mm tons)
ORIGINAL DATA, DESEASONALIZED
SEASONAL VARIATIONS
CYCLICAL VARIATIONS
12 periods
-11.2

CHART 1

The final step is to deseasonalize actual data by applying the seasonal factors (after division by 100) to the original demand figures; these calculations appear on Schedule 3.

Before attempting to isolate the underlying secular trend in this example, a few words concerning the concepts which are implicit in the deseasonalization process would appear to be appropriate.

The deseasonal process described in this essay is designed to eliminate variations associated with both random disturbances and seasonal influences. Reflecting upon the techniques employed, the development of moving quarterly averages, followed by the averaging of quarterly ratios over the years, will usually eliminate most random influences in a time series. Any extremes which escape the averages are eliminated by utilizing the adjusted mean approach which requires that the single highest and lowest ratios be eliminated before the seasonal index is computed.

With respect to isolating seasonal influences, the ratio to moving average approach allows for a determination of the "percentages" which the actual data bear to the quarterly averages. By aligning these percentages (ratios) according to quarters and determining the average ratio per quarter, we employ an effective method for identifying the seasonal variations which may exist in the series.

The justification for undertaking these computations are two-fold:

- For short term forecasts, the isolation of seasonal influences, and utilization of appropriate factors, often will be the primary difference between a useful, accurate projection and meaningless extrapolation.

- For long term forecasts which employ unseasonalized data, an increasing (rising)secular trend would compound seasonal influences, i.e., cause unseasonalized data for the latter months of each year to be higher than for months at the beginning of the year.

One final note of caution is offered. Seasonal variations generally are persistent, regularly recurring influences. However, their pattern <u>can</u> change over time and this possibility should be considered in the evaluation process. An example is when the U.S. auto industry changed their new model year announcement from Spring to Fall some years ago which changed sales patterns.

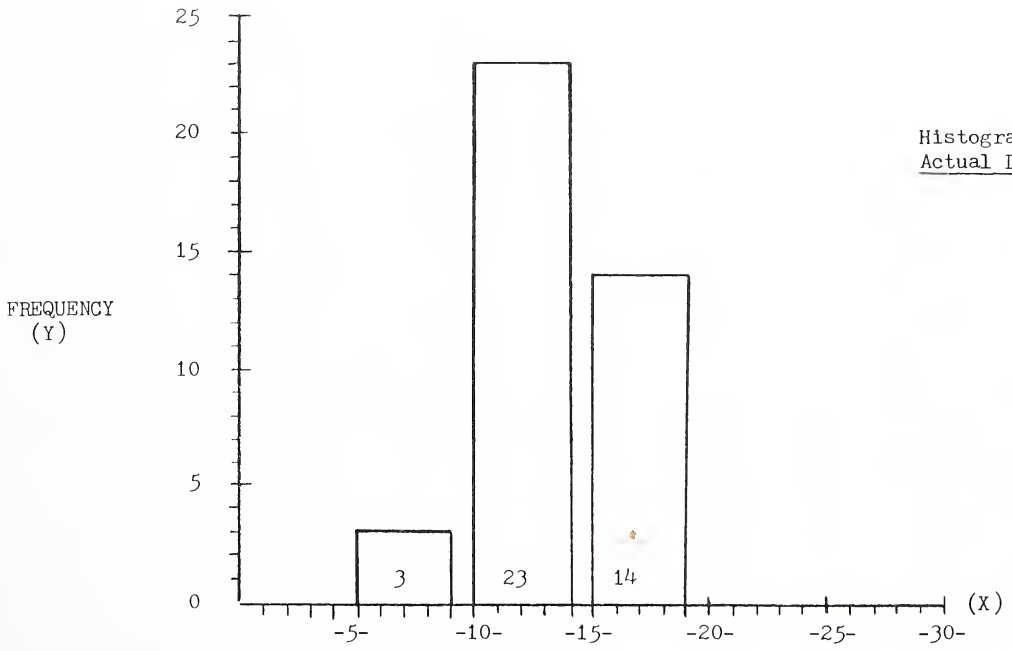
<u>Determine Secular Trend</u>

This process will employ the concepts embodied in 'least squares' computations; an applied mathematical approach often referred to as 'regression analysis'.

You may recall that earlier we defined 'secular trend' as the general movement of data over long periods of time, generally years.

CHART 2

TIME SERIES ANALYSIS



TIME SERIES EXAMPLE
DESEASONALIZATION OF ACTUALS

Schedule 3

Year	Quarter	Demand (MM Tons)	(Seasonal Factor)/ 100	Deseasonalized Demand (MM Tons)
1	1	12	1.017	11.8*
	2	11	.980	11.2
	3	11	.994	11.1
	4	10	1.010	9.9
2	1	9	1.017	8.8
	2	8	.980	8.2
	3	9	.994	9.1
	4	10	1.010	9.9
3	1	11	1.017	10.8
	2	12	.980	12.2
	3	13	.994	13.1
	4	14	1.010	13.9
4	1	15	1.017	14.7
	2	14	.980	14.3
	3	13	.994	13.1
	4	12	1.010	11.9
5	1	11	1.017	10.8
	2	10	.980	10.2
	3	11	.994	11.1
	4	12	1.010	11.9
6	1	13	1.017	12.8
	2	14	.980	14.3
	3	15	.994	15.1
	4	16	1.010	15.8
7	1	17	1.017	16.7
	2	16	.980	16.3
	3	15	.994	15.1
	4	14	1.010	13.9
8.	1	13	1.017	12.8
	2	12	.980	12.2
	3	13	.994	13.1
	4	14	1.010	13.9
9.	1	15	1.017	14.7
	2	16	.980	16.3
	3	17	.994	17.1
	4	18	1.010	17.8
10.	1	19	1.017	18.7
	2	18	.980	18.4
	3	17	.994	17.1
	4	16	1.010	15.8

*Eliminated for Coding Purposes

To determine the secular trend for a series, we will attempt to mathematically fit a curve to the seasonally adjusted data. To simplify the presentation, this essay is confined to describing trend in terms of a straight line fitted to example data. However, in some instances, a curvilinear trend line may provide a better fit to the time series. For further information on appropriate curvilinear equations, readers are referred to any standard math textbook which discusses polynominals and higher order equations.

Before proceeding with the analysis, the following support for utilizing 'least squares' techniques to develop a straight line trend is offered:

- the technique assures that the sum of the vertical deviation... from the fitted straight line to the seasonally adjusted data (if monthly or quarterly values)...will equal zero and,

- the sum of the squares of these same deviations is ... less than... the sum of the squared vertical deviations of <u>any other</u> straight line which can be fitted to the data.

Stated simply, the 'least squares' technique provides the best of all possible "straight" lines which can be used to describe the secular trend of the series.

To expedite trend computations, the first step is to 'code' the time series data. While an even number of data points can be coded, by using an odd numbered time series, the calculations are simplified. For this reason, the deseasonalized demand of 11.8 mm tons for Year 1, Quarter 1 (see top of Schedule 3) has been eliminated; this leaves 39 deseasonalized demand data points, an odd number, in the last column of Schedule 3. This data then was transferred to Schedule 4, Page 1 and appears under the column captioned (Y).

Coding is accomplished by assigning the middle data point (Year 6, Quarter 1) the zero position. Working backward from the middle year, each data point is assigned a minus number, chronologically. Similarly, years following the middle year are assigned a positive number, as shown on Schedule 4 under the column entitled (x). The sum of numbers assigned should be zero.

Next, multiply column (Y) by column (x). Compute (x^2) by squaring the (x) column. Each column then is totaled.

To compute the linear trend line, the equation $Yc = A + B(x)$ is used where, Yc represents an estimate of deseasonalized demand, A is the constant term, B is the regression coefficient (slope of the line) and (x) is any time period as represented by a code from Schedule 4.

Using the information developed on Page 1 of Schedule 4 (and the equations illustrated on Schedule 5), we compute an estimated Yc for three points of the time series. These computations appear on Page 2 of Schedule 4.

These three figures represent the estimated deseasonalized demand which the equation computes versus the deseasonalized actuals. Note that computed demand is within a plus or minus 1.7 million of each actual.

Next, the deseasonalized actuals are plotted on arithmetic paper (upper right portion of Chart 1). The three computed Yc's then are located on the chart, after which a straight line is ruled through the Yc points. This line represents the 'secular trend'.

TIME SERIES EXAMPLE

SECULAR TREND

Schedule 4

Year	Quarter	(Y) Deseasonalized Demand (MM Tons)	(x) Code	(xY)	(x^2)
1	1	-	-	-	-
	2	11.2	-19	-212.8	361
	3	11.1	-18	-199.8	324
	4	9.9	-17	-168.3	289
2	1	8.8	-16	-140.8	256
	2	8.2	-15	-123.0	225
	3	9.1	-14	-127.4	196
	4	9.9	-13	-128.7	169
3	1	10.8	-12	-129.6	144
	2	12.2	-11	-134.2	121
	3	13.1	-10	-131.0	100
	4	13.9	-9	-125.1	81
4	1	14.7	-8	-117.6	64
	2	14.3	-7	-100.1	49
	3	13.1	-6	- 78.6	36
	4	11.9	-5	- 59.5	25
5	1	10.8	-4	- 43.2	16
	2	10.2	-3	- 30.6	9
	3	11.1	-2	- 22.2	4
	4	11.9	-1	- 11.9	1
6	1	12.8	0	0.0	0
	2	14.3	1	14.3	1
	3	15.1	2	30.2	4
	4	15.8	3	47.4	9
7	1	16.7	4	66.8	16
	2	16.3	5	81.5	25
	3	15.1	6	90.6	36
	4	13.9	7	97.3	49
8	1	12.8	8	102.4	64
	2	12.2	9	109.8	81
	3	13.1	10	131.0	100
	4	13.9	11	152.9	121
9	1	14.7	12	176.4	144
	2	16.3	13	211.9	169
	3	17.1	14	239.4	196
	4	17.8	15	267.0	225
10	1	18.7	16	299.2	256
	2	18.4	17	312.8	289
	3	17.1	18	307.8	324
	4	15.8	19	300.2	361
Total		524.1	0	954.5	4940

TIME SERIES EXAMPLE
SECULAR TREND

Linear Trend: $Yc = A + B(x)$

Where: $A = \Sigma Y/N = 524.1/39 = 13.44$

$B = \Sigma(xY)/\Sigma(x^2)$

$= 954.5/4940.0 = .1932$

Therefore:	Yc	=	A	+	B (x)	Memo: Time *
	10.4	=	13.44	+	.1932 (-16)	YR2, Q1
	13.8	=	13.44	+	.1932 (2)	YR6, Q3
	16.7	=	13.44	+	.1932 (17)	YR10,Q2

Standard Error $= \sqrt{\Sigma(Y - Yc)^2/N - 2}$

$= \sqrt{104.85/37}$

$= 1.68 = 1.7$

Standard Dev. $= \sqrt{\Sigma(Y - A)^2/N - 1}$

$= \sqrt{289.27/38}$

$= 2.76$

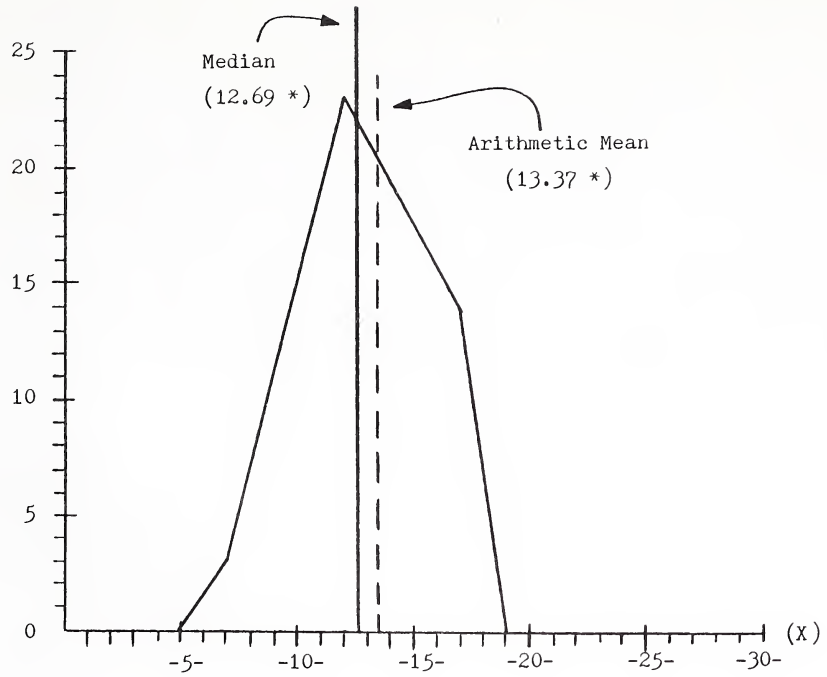
$R^2 = 1 - ((1.68)^2/(2.76)^2)$

$= .63$

$R = .79$

* These time periods were selected for illustration only; all remaining time periods also should be computed. To compute Yc for other time periods, merely substitute the appropriate (x) value (in place of those illustrated) for the time period selected. For other time periods, the values for 'A' and 'B' will be the same as those shown above.

TIME SERIES ANALYSIS



Polygon
Actual Data *

Skew = Positive (+.68)

Standard Deviation = 2.95

Quartiles :

Q1 = 10.52

Q2 = 12.69

Q3 = 15.42

* mm tons; see Schedule 1

After scribing the trend line on Chart 1, the 'standard error' of the line is determined as on page 2 of Schedule 4. The result, 1.7, is an indication of the scatter or variability of the deseasonalized actuals around the Yc line. Simply stated, the Yc line may be visualized as the 'mean' of the deseasonalized actuals and the standard error describes the spread of the actuals around the mean. Obviously, the smaller the standard error, the more indicative will be the equation of the underlying values. Its usefulness, assuming the actuals are normally distributed around the Yc line, can be seen from the following:

Yc Plus or Minus	Percentage of Deseasonalized Actuals Within STD. Error Range
1 STD Error	68 %
2 STD Errors	95.5 %
3 STD Errors	99.7 %

At least two (plus and minus) standard errors should be plotted on each side of the trend line.

Although not illustrated on Chart 1, once plotted, the standard error band should be evaluated to determine if the equation appears to be estimating the series effectively.

A further indication of the equation's effectiveness is gained by computing the Coefficient of Determination (R^2). In our example, this statistic is a measure of the linear association between time (x) and deseasonalized demand (Y). Stated another way, it is the amount of variation in (Y) which is explained by the Yc trend line. It ranges between 0.0 and $\pm$ 1.0 with $\pm$ 1.0 being a perfect correlation, i.e., all deseasonalized demand points lie on the trend line.

While no precise rules exist for determining how high R^2 must be in order to be significant, the following guidelines generally are considered reasonable for identifying potentially useful equations:

Acceptable R^2	Type of Equation
.75 or Higher	All except logarithmic
.50 or Higher	Logarithmic

Of the statistics discussed to this point, perhaps none are more important to the evaluation than is the R^2 result. Since it is a precise, quantitative measure of the degree to which the Yc line explains the variation in Y, any equations which do not result in an acceptable R^2 range should be rejected or reformulated.

Less useful, although frequently computed, is the R statistic, the Coefficient of Correlation (Schedule 5). To some extent, it "describes"how Y, the dependent variable, may vary given changes in the independent variable, x. The sign of R, however, is important for, like the regression coefficient, a positive sign indicates that a "direct" relationship exists between X and Y; a negative sign identifies an "inverse" relationship between the variables.

TIME SERIES EXAMPLE
SECULAR TREND

Schedule 5

Equation:

Trend Line	$Yc = A + B(x)$
Mean, Deseasonalized Demand	$A = \Sigma(Y)/N$ *
Regression Coefficient (Slope), Trend Line	$B = \Sigma(xY)/\Sigma(x^2)$
Standard Error, Trend Line	$Se = \sqrt{\Sigma(Y-Yc)^2/N-2}$
Standard Deviation, Deseasonalized Demand	$Sd = \sqrt{\Sigma(Y-A)^2/N-1}$
Coefficient of Determination	$R^2 = 1-(Se^2/Sd^2)$
Coefficient of Correlation	$R = \sqrt{R^2}$

Note: These equations also may be employed in evaluating correlations between two variables. This is accomplished by substituting independent variable quantities in place of the (x) Codes shown on Schedule 4, page 1. The mean of the independent variable then is determined by the equation $\Sigma(x)/N$. The variance which each independent variable quantity is from the mean of (x) is determined and posted on Schedule 4, page 1; the new column should be entitled (x deviation). The (x deviation) column then is employed for all remaining computations in place of the coded (x) column used in time series evaluations.

* N = the total number of data points in the sample (39 in this example).

Σ = the symbol representing 'the sum of'.

TIME SERIES EXAMPLE
TRENDS: SECULAR AND CYCLICAL

Schedule 6

Year	Quarter	Actual Demand (MM Tons)	(Y) Deseasonalized Demand (MM Tons)	(Yc) Secular Trend *	Cyclical Trend (Relative Residual Method)
1	1	12	-	-	-
	2	11	11.2	9.8	14.3
	3	11	11.1	10.0	11.0
	4	10	9.9	10.2	- 2.9
2	1	9	8.8	10.4 *	- 15.4
	2	8	8.2	10.5	- 21.9
	3	9	9.1	10.7	- 15.0
	4	10	9.9	10.9	- 9.2
3	1	11	10.8	11.1	- 2.7
	2	12	12.2	11.3	8.0
	3	13	13.1	11.5	13.9
	4	14	13.9	11.7	18.8
4	1	15	14.7	11.9	23.5
	2	14	14.3	12.1	18.2
	3	13	13.1	12.3	6.5
	4	12	11.9	12.5	- 4.8
5	1	11	10.8	12.7	- 15.0
	2	10	10.2	12.9	- 20.9
	3	11	11.1	13.1	- 15.3
	4	12	11.9	13.3	- 10.5
6	1	13	12.8	13.4	- 4.5
	2	14	14.3	13.6	5.2
	3	15	15.1	13.8 *	9.4
	4	16	15.8	14.0	12.9
7	1	17	16.7	14.2	17.6
	2	16.	16.3	14.4	13.2
	3	15	15.1	14.6	3.4
	4	14	13.9	14.8	- 6.1
8	1	13	12.8	15.0	- 14.7
	2	12	12.2	15.2	- 19.7
	3	13	13.1	15.4	- 14.9
	4	14	13.9	15.6	- 10.9
9	1	15	14.7	15.8	- 7.0
	2	16	16.3	16.0	- 1.9
	3	17	17.1	16.2	5.6
	4	18	17.8	16.3	9.2
10	1	19	18.7	16.5	13.3
	2	18	18.4	16.7 *	10.2
	3	17	17.1	16.9	1.2
	4	16	15.8	17.1	- 7.6

*See Schedule 4, page 2, for computation examples.

In our example, R is positive, indicating a direct relationship exists between the variables, i.e., demand generally increases over time.

Although we will return to our analysis of secular trend, our next effort should be to identify if any cyclical influences are present in the data.

Isolate Cyclical Influences

Cyclical variations, if any, will be determined by employing an approach termed the 'Relative Residual Method'. This method is appropriate in our evaluation as it naturally builds upon our deseasonalization and secular trend determination processes.

Referring to Schedule 6, we calculate cyclical influences as follows:

1. Divide Y (Deseasonalized Demand) by Yc (Secular Trend) . . . for Year 1 - Quarter 2, the result is 1.143, rounded.

2. Multiply the result from step 1 by 100

3. Subtract 100.0 from the product of step 2 to arrive at the factor 14.3. Being careful to record the resulting sign from each computation, this process is continued for all remaining quarterly data points for the series.

An equation illustrating this process is ((Y/Yc x 100) - 100). The Relative Residual Method yields percentages; these identify how the quarters vary (plus or minus) around the computed secular trend line. Once determined, the percentage factors should be plotted, as on Chart 1 lower right. Note that "zero" is located at the midpoint on the (Y) axis; this allows 'negative' residual percentages to be plotted along with 'positive' figures. From Chart 1, we really can determine that, of all the variations influencing our example time series, none are more pronounced or important that the cyclical patterns which are active. Further, by plotting the cyclical patterns using the method described, we create a 'reference point', the secular trend line (zero line), against which the cyclical wave variations can be evaluated.

Since the cyclical influences are pronounced in our example, we must quantitatively analyze the historic wave patterns, determine if the patterns are changing and attempt to project the cyclical variations forward to the 'target' forecast quarter. For this example, we have selected Year 11, Quarter 4, as the target.

Our first step is to evaluate the cyclical wave period as measured from trough to trough. This is accomplished by reviewing Chart 1 and simply counting the number of quarters or periods between each trough. Based on historic patterns, we assume that the periods between troughs will remain at 12 and, therefore, forecast the next trough for the second quarter of Year 11. If the periods (number of quarters) between each historic trough had varied, it would be necessary to analyze each period and determine the rate of period change which has occurred. The result then would be used to forecast when the next trough should occu

To determine the 'depth' of the projected trough, we evaluate the changes which have occurred during the prior cycles; computations are shown on Schedule 7, Item 1. Since the depth of prior troughs has diminished over time, we have averaged the trough to trough changes to arrive at a mean of +1.1%. This mean appears to be conservative and appropriate for our example.

TIME SERIES ANALYSIS
CYCLICAL VARIATIONS

Schedule 7

Cyclical Variations: Forecast

1. Analysis: Depth of Prior Troughs

Trough	Residual Percent	Change %	Memo: Periods Between Troughs
1 (Yr 2, Qtr 2)	-21.9%	-	-
2 (Yr 5, Qtr 2)	-20.9%	+1.0	12 Qtrs
3 (Yr 8, Qtr 2)	-19.7%	+1.2	12 Qtrs
		+1.1 (Mean)	

Therefore:
Trough 4 (Forecast) = (-19.7, Trough 3) - (+1.1, Mean Change Between Troughs)
= -18.6 (Yr 11, Qtr 2)

2. Analysis: Prior Slopes, Trough to Yc Intercept (Refer to Chart 1)

Simple Slope = Y2-Y1/X2-X1 Where: Y=%; X = Time

Trough 1 = (-21.9 - 0.0)/(Yr 3, Qtr 1.5 - Yr 2, Qtr 2)
(To Intercept)= (+21.9)/(3.5 Qtrs)
= +6.3% (rounded) Slope Change Per Quarter

Trough 2 = (-20.9 - 0.0)/(Yr 6, Qtr 1.5 - Yr 5, Qtr 2)
(To Intercept)= (+20.9)/(3.5 Qtrs)
= +6.0% (rounded) Slope Change Per Quarter

Trough 3 = (-19.7 - 0.0)/(Yr 9, Qtr 2.25 - Yr 8, Qtr 2)
(To Intercept)= (+19.7)/(4.25 Qtrs)
= +4.6% (rounded) Slope Change Per Quarter

Schedule 7

Trough	Slope Change Per Quarter	Change
1	+ 6.3%	-
2	+ 6.0%	-.3%
3	+ 4.6%	-1.4%
		-.9% (Mean, rounded)

Therefore

Forecast Slope: Trough 4 to Intercept = (4.6%) + (-.9%)
= 3.7% Expected Change Per Quarter

Forecast Cyclical Factor = (-18.6) - (+3.7 x 2 Qtrs)
For Year 11, Quarter 4 = (-11.2%)

As illustrated on Schedule 7, Item 1, the depth of the forecast trough is determined by subtracting the mean change (+1.1) from the actual depth (-19.7) of the last trough. The result . . . . -18.6 . . . . . is plotted on Chart 1 and visually evaluated for reasonableness.

Since the forecast trough occurs on Year 11, Quarter 2, which is two quarters short of our target forecast quarter, namely Year 11, Quarter 4, we need to estimate the cyclical influence expected for the target quarter. This is accomplished by computing the positive slope of the line for each prior trough, i.e., trough to intercept of secular trend line. These calculations then are arrayed, as on Schedule 7, Item 2, and evaluated. Note that the slope (rate of change per quarter) is decreasing over time. This finding is not surprising since, by close inspection of Chart 1, we note that the cycle wave amplitude is decreasing over time and the period, as measured by the number of quarters to trend line intercept, is increasing slightly. Specifically, trough 3 intercept occurred in 4.25 quarters after the trough, whereas trough 1 and 2 intercepts occurred in 3.5 quarters following the trough.

Armed with these discoveries, we forecast the expected slope change for each quarter from trough 4 to the intercept with the Yc Secular Trend Line. As shown on Schedule 7, item 2, this results in an expected change per quarter of 3.7%.

Since we previously forecast that trough 4 will occur in Year 11, Quarter 2, two quarters short of our target forecast period (Year 11, Quarter 4), we merely multiply the expected slope change per quarter by two quarters (3.7% x 2) and subtract the result from trough 4 (ie, -18.6%). From these calculations, we determine a cyclical factor of -11.2% which should apply for the target period . . . Year 11, Quarter 4. This factor then is plotted as a percent on the bottom of Chart 1.

Forecast Time Series

Having eliminated the random variations as well as isolated the seasonal, secular and cyclical influences which are active in our time series example, we now are prepared to begin the serious business of forecasting commodity demand for Year 11, Quarter 4.

This is accomplished in several steps. First, we utilize our secular trend equation . . . Yc = A + B (x) . . . to determine the deseasonalized demand expected for Year 11, Quarter 4. Computations, shown on Schedule 8, yield a result of 17.88 tons.

However, we identified earlier that this series is influenced by positive "seasonal" variations in the last quarter of each year. Thus, we 'seasonally adjust' the result provided by the equation; this merely requires that the 17.88 tons be multiplied by the appropriate seasonal factor (101.0/100), as shown on Schedule 8.

If our series was not affected by cyclical influences, the seasonalized forecast of 18.06 tons would be the projected demand for Year 11, Quarter 4. As we previously calculated, however, a negative cyclical influence of -11.2% is projected for our target quarter.

We further adjust for this influence, as shown on Schedule 8, to derive the "most likely" forecast for the target quarter of 16.04 tons; an estimate which is comparable to the original data we plotted for our time series example on the upper left portion of Chart 1.

TIME SERIES EXAMPLE
FORECAST AND ADJUSTMENTS

Schedule 8

Forecast: Yc = Forecast Demand - Year 11, Quarter 4

= A + B (x)

= 13.44 + .1932 (23)*

= 17.88 Tons (UNADJ. For Seasonal & Cyclical Variations), MM

Adjustments: Yc (Seasonally Adjusted) = 17.88 x (101.0/100)

= 18.06 Tons , MM

Yc (Cyclically Adjusted) = 18.06 x ((100.0 -11.2)/100.0)

Year 11, Quarter 4 = 16.04 Tons (Forecast Demand, ADJ.), MM

* Note: Year 11, Quarter 4 is four (4) time code periods beyond Year 10, Quarter 4 which was coded 19. Therefore, 19 + 4 = 23.

Having developed our final estimate, we plot our result on Chart 1 (not illustrated) and compute a target forecast range using plus and minus two standard errors, adjusted for seasonal and cyclical variations (if any). In practice, the final or target quarter should be plotted on the upper left portion of Chart 1, along with all intermediate points between the target and the end of original data.

You may recall that one standard error was equal to 1.7 tons (Schedule 4, page 2). Thus, two standard errors equal 3.4 tons (i.e., 2 x 1.7) before seasonal and cyclical adjustments are applied. These adjustments may be handled as follows:

1. Determine a single factor which comprehends both seasonal and cyclical influences. For our example, this is accomplished by the following. . . ((Seasonal Factor) + (Cyclical Factor))/100 or, ((101.0) + (-11.2))/100. The result computed by this method is .898.

2. Multiply the single adjustment factor by the figure which is equal to 2 standard errors, i.e., (.898) x (3.4), to determine the value of 2 adjusted standard errors. For our example, the result is 3.05 MM tons.

Once two adjusted standard errors are computed, we calculate a forecast range for the target quarter by adding and subtracting 3.05 MM tons to our "most likely" forecast for Year 11, Quarter 4, namely 16.04 MM tons.

	Low Parameter (Tons) MM	High Parameter (Tons) MM
Most Likely	16.04	16.04
2 Std. Errors	- 3.05	+ 3.05
Forecast Range	12.99	19.09

Conclusion

To accomplish our forecast, we have secured a series of raw data which represents quarterly commodity demand over a period of ten years. We then decomposed the data to eliminate and/or isolate four significant influences which were found to be active in the original data, namely: random, seasonal, cyclical and secular variations.

Using decomposed data, we forecasted expected commodity demand and then adjusted or restated the forecast to reflect the projected seasonal and cyclical influences which may continue to be active in the future. The restated figures represent our "most likely" projection of future demand which any reader (who may be unfamiliar with the techniques exposed in this essay) should be able to use without further explanation.

Since projecting the future is a risk-laden venture, we completed our forecast by developing a forecast range through the use of two standard errors.

This forecast range is significant to us for it is a calculated probability of 95.5% that future demand will fall within our forecast range. Stated another way, the probability that our forecast range is incorrect is 4.5% (100.0 - 95.5%). These probabilities apply only if we are correct in assuming the following:

- The actual values (commodity demand) are normally distributed, as in the bell curve, around the computed secular trend line and around each computed Yc.

- The underlying structures and forces which were operative in the industry and/or company from which our data was secured will be applicable in the future and at the same or similar intensities as the past. Further, that war, revolution, strikes or acts of God will not occur during the forecast period.

These assumptions cannot be casually made; appropriate analysis effort should be invested to assure their validity, to the extent possible.

With respect to the first assumption concerning a normally distributed population or sample, descriptive statistical methods exist, as in Appendix 1, for estimatin the inherent nature of data.

In conclusion, it is believed that the practical approach and method described herein will be found by business planners to be of significance in improving the accuracy of forecasts, particularly in the areas of industry and commodity studies.

References:

APPLIED GENERAL STATISTICS by Croxton, Cowden & Klein; 3rd Edition; Published by Prentice Hall, Inc.

STATISTICS AS APPLIED TO ECONOMICS AND BUSINESS by Wessel, Willett & Simone; Revised Edition; published by Holt, Rinehart & Winston, Inc.

STATISTICS FOR MANAGEMENT by R. I. Levin; Published by Prentice Hall, Inc.

DESCRIPTIVE STATISTICS
APPENDIX I

In dealing with population or sample data, it is essential to determine the extend to which the statistics being utilized are normally distributed around a central point.

Numerous computational measures exist for determining the central tendency of data; examples of which include:

- arithmetic mean
- Harmonic mean
- geometric mean
- median
- mode
- quartiles
- inter-quartile ranges
- quartile deviation
- standard deviation
- skew

Each measure posesses inherent benefits and potential evaluation risks, depending upon the application to which the measure is applied.

Since many company computer libraries include statistical evaluation programs with a number of descriptive statistic measures, this Appendix will discuss the application, rather than the method of calculation, of several useful measures.

General

Data is normally described using grouped or ungrouped data. As the term implies, ungrouped data is raw data which has not been arrayed in any order. Conversely, grouped data is ordered data. To illustrate the difference, we will order or group the actual demand data (mm tons) which appear on Schedule 1. To accomplish this, we select 'class intervals' or ranges in which the actual demand figures will be counted to determine their frequency of occurrence:

Class Interval	Frequency
0 - 4	0
5 - 9	3
10 - 14	23
15 - 19	14
20 - 25	0

With this simple ordering of the data, we have greatly simplified the analysis effort required to describe the sample or population data.

For example, on Chart 2, we have plotted a histogram which graphically describes the series. Note that class intervals were utilized along the (X) axis with frequencies appearing on the (Y) axis.

Perhaps even more useful is graphically representing the date by construction of a polygon, as on Chart 3.

The graph is similar to Chart 2, except the midpoint only of each class interval has been used.

Appendix 1

The balance of this Appendix will deal with Chart 3.

Note that we have ruled two lines; one represents the arithmetic mean and the second identifies the location of the median.

The mean, which in this example is 13.37 tons, is an average which considers all actual demand data points which appear in the 3rd column (from left) on Schedule 1. The median, computed at 12.69, is the number above and below which 50% of the data points are located.

In a normally distributed sample or population, the median and mean would be equal and the polygon would appear as a "perfect" bell-shaped curve. Obviously, these "perfect" relationships seldom occur in business. Very frequently, however, business data will closely approximate the normal (bell-curve) distribution and it is this close approximation we are seeking, as in our example on Chart 3.

Specifically, the Chart illustrates that the distribution closely parallels the normal curve since the median and mean are only .68 MM tons apart. In other words, the curve in our example is slightly skewed in a positive fashion with the arithmetic mean to the right of the median. This relationship indicates that demand data is more concentrated towards the lower class intervals of the distribution curve than the higher intervals.

If the skew was "negative", the arithmetic mean would be to the left of the median and the data would, therefore, be concentrated more toward the higher class intervals than the lower intervals.

As with standard errors, standard deviations provide a way for assigning probabilities regarding how the data is distributed. Probability percentages are the same as those for the standard error:

Arithmetic Mean Plus or Minus	Percentage of Data Points Within Std. Dev. Range
1 STD. Deviation	68.0%
2 STD. Deviations	95.5%
3 STD. Deviations	99.7%

Quartiles also provide a method for determining how data is distributed in our sample or population.

Quartile interpretations follow :

Q1 - 25% of the data is below this point

Q2 - 25% of the data is between Q1 and Q2

Q3 - 25% of the data is between Q2 and Q3 and, 25% is above Q3.

These quartile facts allow other equally valid interpretations, such a. 75% of the data is less than Q3, etc.

In conclusion, we suggest these descriptive methods be used to assure that data employed for commodity and industry forecasts are normally distributed and can, therefore, be evaluated effectively by the methods described in this essay.

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New Records of Vascular Flora from Gloucester County, Virginia

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Abstract--Gloucester County is located on the Middle Peninsula of Virginia. Beaverdam Swamp was the major collecting area. Nearly 800 species of vascular plants were collected and identified, 562 of them newly recorded here. A phytogeographic comparison was made of the plant assemblages of Gloucester County and four other Virginia locations.

Introduction

A floristic survey of Gloucester County, Virginia (Figure 1), was conducted from spring 1975 through fall 1977. The purpose of the survey was to collect and identify the vascular flora of the county, with an emphasis on one of its major watershed areas, Beaverdam Swamp. Gloucester County is located on the southeast end of the Middle Peninsula, an area comprised of six counties, extending from the Fall Line of the Piedmont to the Chesapeake Bay, and bordered on the north by the Rappahanock River and on the south by the York River. Gloucester County is bordered on the north by the Piankitank River and Dragon Run Swamp, on the east by Mathews County and Mobjack Bay, on the south by the York River, and on the west by King and Queen County and Poropotank Creek.

This was the first major floristic work on the Middle Peninsula since the mid-1700's. Collecting trips were made throughout the county during the entire year, concentrating on the spring and summer months. Nearly 800 species of plants in 123 families were collected and identified, bringing the total known species from the county to over 900 in 127 families. The collection is deposited in the herbarium of the College of William and Mary (WILLI), Williamsburg, Virginia.

Description of the County

Elevations in the county are from sea level to over 130 feet near Glenns (Figure 1). There are three major topographic features in Gloucester, three terraces formed by the advancing and receding sea during the Pleistocene. These are Princess Anne, Yorktown, and Wicomico, with elevations of sea level to about 30 feet, 30 to 90 feet, and 90 to 130 feet, respectively. Vegetational characteristics of the lower terraces resemble the other southern coastal Virginia locations, while the upper terrace and associated vegetation resemble the Piedmont.

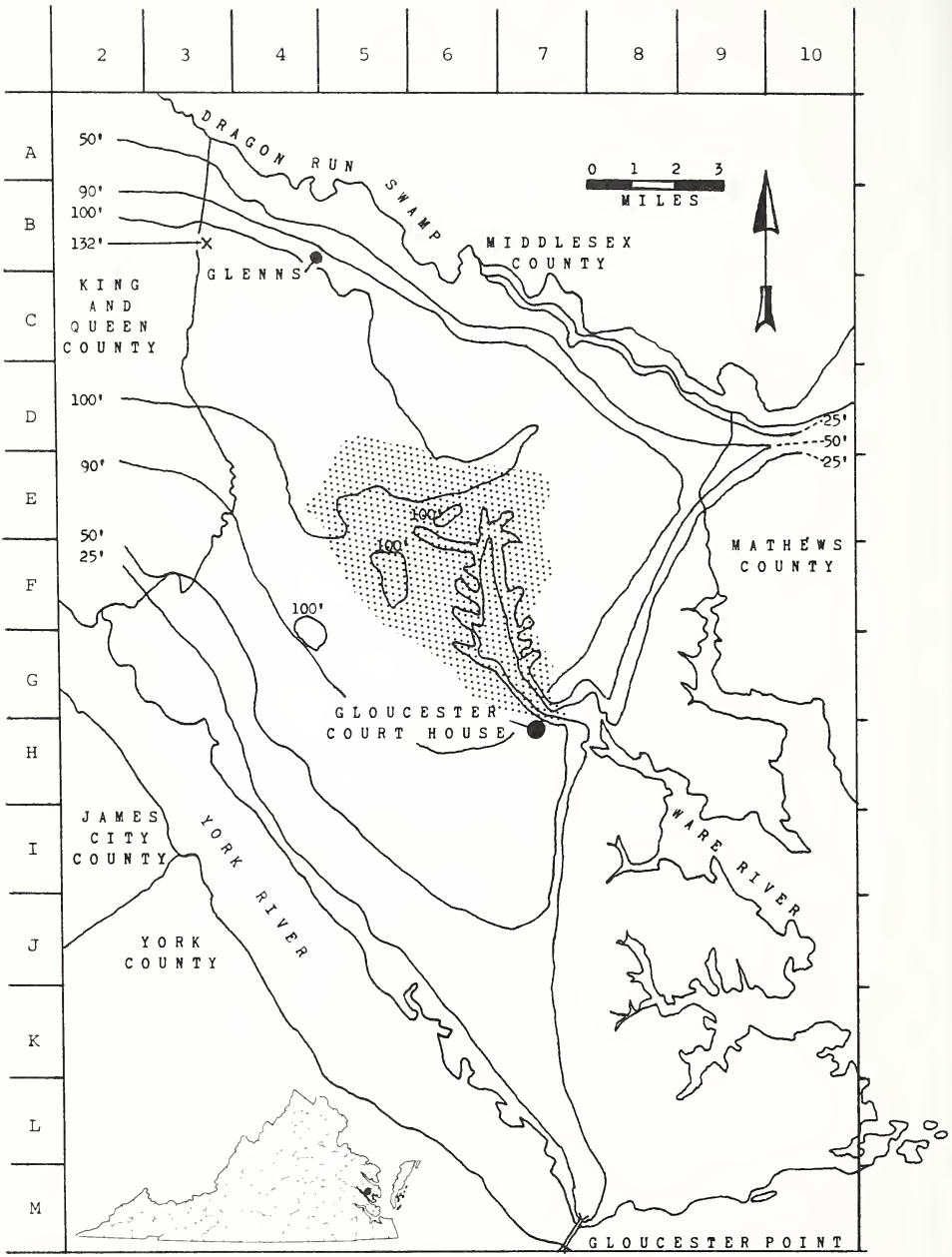

Figure 1. Grid map of Gloucester County, Virginia, showing topographic elevation outlines, and Beaverdam Swamp, depicted by speckling.

The Princess Anne terrace accounts for about 17 percent of the area of the county, with a third of this as marshes and tidal flats. Topographic boundaries between Princesss Anne and Yorktown are most obviously seen as abrupt slopes parallel to Routes 3 and 14 east and northeast of Gloucester Court House. In many places along the York River, this boundary is eroded bluffs, and sloping shorelines, visible from across the river.

The Yorktown terrace comprises about 35 percent of the area of the county. Its precise upper limits are not as easily discernible as in Princess Anne, but there are many steep ravines and hills that give this terrace its characteristic habitats and make it important vegetationally. Many spring-fed streams are found cutting through the terrace, draining the uplands and carrying acidic soils into lower sections of Yorktown and Princess Anne terraces. Soils range from well-drained, alkaline sandy loams to tightly-packed acidic clays found in bogs and swales. Vast areas of marl underlying the county are exposed by many of the major ravines and water-courses. Thus, many of the significant habitats of the county are found within Yorktown formations.

About 30 percent of the county is above 90 feet, and is within the Wicomico formation. Soils are generally well-drained sandy to pebbly loams, creating fairly depauperate conditions for vegetational diversity. However, because of the level nature of much of this terrace, there are several large expanses of bog and pine barren-like areas north and east of Beaverdam Swamp. The remaining 18 percent of the county is within the 50-90 foot elevation range, and is made of those areas that began as high uplands, but have had ravines cut into, and had great amounts of soil eroded away from, the upper two terraces. Many significant plant species were found associated with these watershed areas; however, more floristic work is needed in the northern uplands of the county to determine the significance of the unusual species found during the survey of Beaverdam Swamp.

Major forest types are Maple-Gum-Oak in and near swamps, and Beech-Oak-Hickory on drier sites on slopes and uplands. Pure and mixed pine forests can be found throughout the county as cultivars, as well as second-growth forests on old fields. Several streams and many of the shoreline coves harbor large stands of Baldcypress, and Dragon Run Swamp contains the largest contiguous forest of the species inland and north of Dismal Swamp. Sub-dominants include Ash, Elm, Blacklocust, Birch, Sweetgum, Hackberry, Redcedar, and some smaller oaks.

Discussion

The Beaverdam Swamp was the major study area. Its watershed drains sections of all three terraces, and covers about 24 square miles. Although it is isolated from contact with other drainages on the Middle Peninsula, this area may contain one of the richest assemblages of vegetation types and highest plant species diversity of comparably sized areas on Virginia's Coastal Plain. Many generally southern species (Table II) were found at lower elevations in the swamp (as at other, less isolated coastal locations), while a significant number of northern species were found at higher elevations within Beaverdam watershed. Many apparently relict northern species (e.g., Lycopodium luciculum) were found in upper areas of the watershed, or in cool, shaded ravines about seeps or springs where soil conditions favor their continued survival.

Table 1. Phytogeographic range designations for species of plants found in Virginia.

Range	Description of range limitations
1	Circumboreal (totally or interrupted)
2	Native to North America and Eastern Asia
3	Ranging west to Pacific coast (native North American)
	3a Uninterrupted distribution
	3b Interrupted distribution: found on both coasts
4	Ranging southward beyond the United States
5	Ranging from eastern North America to west of Mississippi River, but not to Pacific coast
	5a Generally distributed north and south
	5b Generally northern in distribution
	5c Generally southern in distribution
	5d Generally distributed along the coastal plain and the Mississippi Valley, extending westward beyond the Mississippi River in the north
	5e Generally distributed along the coastal plain and the Mississippi Valley, extending westward beyond the Mississippi River in the south
6	Limited to eastern North America, east of the Mississippi
	6a Generally distributed north and south
	6a1 Extending widely beyond the coastal plain
	6a2 Mostly limited to the coastal plain
	6b Generally northern in distribution
	6c Generally southern in distribution
7	Introduced species: not native to North America
8	Cosmopolitan and nearly cosmopolitan species

Small colonies of Thalictrum polygamum and Cardamine douglassii were found at scattered stations throughout the county, and one small colony of Anemone quinquefolia was located in Beaverdam's upper drainage. A few mountain-coastal plain disjuncts were found, such as Carex seorsa and C. leptalea. Viola conspersa was found in a mesic deciduous upland woods near a colony of Lycopodium lucidulum. This species is uncommon in eastern North America, and had been reported in Virginia from Campbell County by Massey (1961), and Floyd and Lee and Wise Counties, and recently collected in James City and York Counties (Donna M. E. Ware, pers. com., 1981). No records have been reported from the central Piedmont. Salvia pratensis and Leontodon nudicaulis are newly reported for the state, collected by Samuel Janney from his farm and Ware Churchyard.

Phytogeographic range designations were assigned to each species (Table I), adapted from Corcoran (1977) and Harvill (1973a). Comparisons were made between the plant assemblages of Gloucester County and those of four other sites: Fort Eustis, Powhatan, Fluvanna, and Rockingham Counties (one coastal and

Table 2. Percent composition of the total flora of the five study sites compared. Percent composition of the northern and southern elements native to North America (see Table 1 for range designation descriptions).

	Ft. Eustis* N = 538	Gloucester** 791	Gloucester** 912	Powhatan* 814	Fluvanna* 748	Rockingham* 500
Range						
1	2.8	2.3	2.4	2.5	2.7	2.6
2	1.1	1.1	1.0	1.0	1.2	1.4
3	4.6	3.5	3.8	4.0	3.6	6.4
3a	3.7	2.5	3.0	3.3	3.1	5.6
3b	0.9	1.0	0.9	0.7	0.5	0.8
4	15.9	11.1	10.9	10.8	10.0	6.2
5	49.8	48.7	48.0	55.0	55.7	53.4
5a	41.0	39.3	36.5	49.7	50.9	49.6
5b	0.4	1.1	1.8	2.1	2.1	3.2
5c	1.5	0.8	2.1	1.0	0.7	---
5d	0.2	0.4	0.5	---	---	---
5e	6.7	7.1	7.1	2.2	2.0	0.6
6	3.1	7.8	8.2	4.2	5.3	9.4
6a	2.0	4.4	4.5	2.8	4.1	6.4
6a1	1.3	3.2	2.9	2.7	3.8	6.4
6a2	0.7	1.3	1.6	0.1	0.3	---
6b	---	1.1	1.2	0.4	0.4	1.0
6c	1.1	2.3	2.5	1.0	0.8	1.8
7	20.5	23.9	22.2	21.4	20.2	19.2
8	2.0	1.5	2.1	1.1	1.3	1.4
Northern (5b5d6b)	0.6	2.6	3.5	2.5	2.5	4.2
Southern (5c5e6c)	9.3	10.2	11.7	4.2	3.5	2.4

*Data obtained from Corcoran (1977).

**Data obtained from this study, including all known species found in the county (912) and those collected for the study (791).

three inland)(Table II). Ranges were adapted from the above works, Britton and Brown (1913), Fernald (1950), Gleason (1952), Gleason and Cronquist (1963), and Munz (1968).

Some general trends are evident in the floristic compositions of the study sites: as one moves from the Coastal Plain (Fort Eustis and lowlands of Gloucester through the upper Coastal Plain (Beaverdam Swamp watershed and the uplands of Gloucester) and Piedmont (Powhatan and Fluvanna Counties) to the mountains (Rockingham County), southern coastal elements (Ranges 4, 5c, and 5e) decrease in importance in regional floristics, progressively (though not entirely) replaced by northern (Ranges 5b and 6b) and generally distributed (Ranges 3a, 5a, and 6a1) elements. However, some floristic groups (Ranges 1, 2, 6a2, 6c, and 8) do not appear to have the same discernible pattern of replacement with other groups. This may be due to the older age of many of the circumboreal and cosmopolitan types, many of which range widely across North America and the northern hemisphere, long adapted to broader

climatic and physiographic conditions than the other species. The floristic composition of Gloucester County seems to cover a broader range of types than its location on the Coastal Plain might suggest. Higher than expected percentages of Range 6 elements in Gloucester may account for some of this difference. In addition, a larger over-all collecting area, encompassing coastal and upland habitats would tend to better reflect the nature of Gloucester's floristics than the relatively narrow constraints placed on the other collection sites compared. The few mountain-coastal plain disjuncts and large number of northern elements found in Gloucester are of great importance in explaining some of the difference between the floristics of Gloucester and Fort Eustis. Elevation of Fort Eustis is limited to below 35 feet, while much of the Gloucester collection came from above that level.

It is interesting to note the corresponding percents of Gloucester's and Fort Eustis' southern elements, the closeness of Gloucester to both Piedmont locations in northern elements, the general trend downward from mountain to coast of northern elements, and the reverse trend in southern elements. The southern Coastal Plain of Virginia marks two major boundaries: the line between the Southeastern Evergreen Forests and the Oak-Pine Forest of the Piedmont and northern Coastal Plain; and, the border between the Grey-brown podzolics of the northern Piedmont and Coastal Plain and the Wesseboden ground-water podzol and half-bog soils of the Coastal Plain south of James River (Braun, 1950). These physical features, combined with evidence from the floristics of Middle and lower peninsulas suggests that the inner Coastal Plain of southern Virginia may have acted as a pivot around which northern and southern floristic elements fluctuated during major climatic upheavals of the Pleistocene. The floristic composition of Gloucester is significant to further refining the history of the flora of Virginia, and increasing knowledge of the rarer elements of that flora, such as coastal-mountain disjuncts.

Checklist

Each species in the following list is newly reported for Gloucester County. Information was derived from Harvill (1966, 1972, 1973a), Massey (1961), and Wass et al. (1972). Many of the records from this study are included in the Atlas of the Virginia Flora (Harvill et al., 1977 and 1981). Nomenclature follows Radford, Ahles, and Bell (1964), and Hitchcock (1935). Forms and varieties of Pteridophytes were found in Cobb (1956). Each entry contains an abundance description (R = rare, or single colony; U = uncommon; O = occasional; C = common; A = abundant), habitat description (a = moist deciduous; b = dry deciduous; c = moist pine; d = dry pine; e = mixed woods; f = cultivated fields; g = open moist; h = open dry; i = freshwater marshes, bogs; j = open wet; k = uplands; l = lowlands; m = springs; n = swamps; o = flowing water; p = ponds; q = brackish; r = streamsides, banks; s = saltmarshes; t = tidal flats; u = dunes, beach strand; v = slopes; w = walls; x = waste areas, old fields; y = yards, gardens; z = roadsides, man-made ditch), phytogeographic category (Table I), collection number(s), and location on a grid map. A large scale grid map used during the study, with route numbers and towns, is filed with the collection. An "*" preceding a species name indicates a new state record.

EQUISETACEAE Equisetum arvense L. O, jnr, 1, #465, G-6. E. hyemale L. U, ajn, 1, #661, G-8. *LYCOPODIACEAE* Lycopodium lucidulum Michaux. R, aklmnr, 5b, #1546, F-7; other #'s 581, 974, 1551. *OPHIOGLOSSACEAE* Botrychium biternatum (Sav.) Underwood. R, aev, 5e, #957, G-6. B. dissectum var. dissectum Sprengel. C, aev, 5a, #711, G-6. B. dissectum var. obliquum (Muhl.) Clute. U, aev, 4, #972A, D-7. *PTERIDACEAE* Adiantum pedatum L. U, aekv, 2, #468, G-6. Dennstaedtia punctilobula (Michaux) Moore. O, bejrz, 5a, #859, F-6. Pteridium aquilinum (L.) Kuhn. C, dhyz, 1, #307, E-8. *ASPIDIACEAE* Athyrium asplenioides (Michaux) A. A. Eaton. A, aez, 5a, #805, G-7. Polystichum acrostichoides (Michaux) Schott. A, abcdegry, 4, #260, G-6. P. acrostichoides forma crispum. O, ae, #926, G-6. P. acrostichoides forma incisum. R, ae, #538, D-7; #1920, G-6. Thelypteris hexagonoptera (Michaux) Weatherby C, aemr, 5a, #469, G-6. T. noveboracensis (L.) Nieuwland. C, aer, 5a, #543, F-5. T. palustris Schott. C, gjmrz, 8, #853, F-6. Woodsia obtusa (Sprengel) Torrey. R, w (Ware Church), 5a, #580, G-7. *BLECHNACEAE* Woodwardia areolata (L.) Moore. C, aen, 5a, #545, F-5. *ASPLENIACEAE* Asplenium platyneuron (L.) Oakes. A, abehvyz, 5a, #265, G-6. *POLYPODIACEAE* Polypodium polypodioides (L.) Watt. R, on trees, 4, #967, H-7; #976, D-6. *AZOLLACEAE* Azolla caroliniana Willd. O, p, 4, #1527, I-6. *PINACEAE* Pinus virginiana Miller. A, cdekl, 6al, #1557, J-5. *TYPHACEAE* Typha glauca Godron. O, ijn, 8, #524, D-7. T. latifolia L. A, jln, 1, #1459, G-7. *ZOSTERACEAE* Potamogeton crispus L. C, op, 7, #1617, J-6. *HYDROCHARITACEAE* Vallisneria americana Michaux. O, inop, 5a, #986, D-6. *POACEAE* Agrostis perrenans (Walter) Tuckerman. C, ce, 4, #1366, F-5. Andropogon gerardii Vitman. C, fghy, 5a, #1493, G-7. A. ternarius Michaux. O, fy, 5a, #1881, K-6. A. virginicus var. abbreviatus (Hackel) Fernald & Griscom. O, el, 4, #903, L-10. A. virginicus L. A, fyz, 4, #952, G-6. Anthoxanthum odoratum L. A, hyx, 7, #102, G-6. Arthraxon hispidus var. cryptatherus (Hackel) Honda. C, gfz, 7, #869, L-9. Arundinaria gigantea (Walter) Muhl. R, clr, 5e, #1547, G-3. Avena sativa L. C, fhyzx, 7, #344, K-8. Bromus commutatus Schrader. U, hz, 7, #A-14, J-5. B. sterilis L. U, h, 7, #1625, G-7. Calamagrostis cinnoides (Muhl.) Barton. O, aexz, 6b, #1437, E-7. Dactylis glomerata L. A, hz, 7, #A-19, J-5. Danthonia spicata (L.) Beauvois ex R. & S. C, hrz, 3a, #298, E-8; #1156a, F-7. Digitaria sanguinalis (L.) Scopoli. A, efghyzx, #918, G-6. Echinochloa crus galli (L.) Beauvois. C, glyz, 7, #627, K-8. E. walteri (Pursh) Heller. U, Haynes Mill Pond, 5a, #1525, J-6. Eleusine indica (L.) Gaertner. A, ghyxz, 7, #A-1, K-6; #1878. Elymus riparius Wiegand. R, zr, 5a, #563, E-9. Eragrostis cilianensis (All.) Lutati. R, hy, 7, #1364, G-7. E. pilosa (L.) Beauvois. O, fhz, 7, #1869, I-7. E. refracta (Muhl.) Scribner. O, grz, 5e, #856, F-6. E. spectabilis (Pursh) Steudel. C, beh, 5a, #813, G-7. Festuca arundinacea Schreber. U, az, 7, #1278, H-7; #1310. F. myuros L. O, fhyz, 7, #A-16, J-5. F. obtusa Biehler. C, egz, 5a, #379, G-6; #1628. Hordeum pusillum Nuttall. C, ghyzf, 4, #287, J-5. H. vulgare L. O, yz, 7, #1225, K-6. Leersia oryzoides (L.) Swartz. C, agnrxz, 8, #1419, F-7. L. virginica Willd. C, enr, 5a, #1368, G-6. Leptochloa filiformis (Lam.) Beauvois. A, ghxy, 4, #490, K-5. Lolium multiflorum Lam. A, efghyz, 7, #395, G-4. Melica mutica Walter. C, befh, 5a, #334, G-7. Microstegium vimineum (Trinius) A. Camus. U, lxz, 7, #447, F-3. Panicum boscii Poiret. C, exz, 5a, #574, E-8. P.

dichotomiflorum Michaux. C, lrz, 4, #900A, L-9. P. ensifolium Baldwin ex Ell. R, ac, 6c, #304, E-8. P. lanuginosum Ell. C, be, 3a, #327, K-7. P. latifolium L. R, kz, 6b, #382, G-6. P. laxiflorum Lam. O, ae, 4, #1145, F-7. P. longiligulatum Nash. O, be, 6a, #328, K-7. P. microcarpon Muhl. R, az, 5e, #773, K-7. P. trifolium Scribner & Merrill. R, nr, 6c, #300A, E-8. P. verrucosum Muhl. C, ce, 5a, #1511, J-6. Paspalum dilatatum Poiret. A, ghyxz, 7, #A-2, K-6. P. floridanum Michaux. C, grxz, 5e, #885, L-9. P. laeve Michaux. O, gh, 5a, #1283, H-7; #1303. P. setaceum Michaux. O, hxyz, 5a, #A-8, K-6. Phalaris canariensis L. R, y, 7, #1764, K-6. Phleum pratense L. C, fhyx, 7, #361-a, G-6. Poa annua L. O, fghyz, 7, #A-32, G-8; #1868. P. autumnalis Muhl. O, aek, 6a, #1156, F-7. P. compressa L. C, aeh, 7, #1143, I-6; #A-17, J-5. P. cuspidata Nuttall. U, egh, 6al, #108, G-7. P. pratensis L. C, ghyz, 8, #1030, G-7; #88, J-5. Polypogon monspeliensis (L.) Desf. O, st, 7, #458, L-10. Setaria faberi W. Herrmann. U, cegz, 7, #625, K-8; #1438, E-7. S. viridis (L.) Beauvois. O, fhyx, 7, #1308, K-6; #1431. Sphenopholis nitida (Biehler) Scribner. R, aegl, 6al, #1101, I-6; #1142, F-7. Sporobolus poiretii (R. & S.) Hitchcock. C, fghyxz, 7, #A-7, K-6. Tridens flavus (L.) Hitchcock. C, aeghyz, 5a, #1474, G-7. *CYPERACEAE* Carex amphibola Steudel. O, bdz, 5a, #1160, F-7. C. blanda Dewey. U, ag, 6a, #1609-b, G-7. C. digitalis Willd. C, aev, 5a, #1153, F-7. C. flaccosperma Dewey. O, anr, 5c, #1401, H-7; #1771, G-7. C. leptalea Wahlenberg. C, jnr, 3a, #1374, F-7. C. nigromarginata Scheinitz. C, be, 3a, #1161, F-7. C. physorhyncha Liebmann. U, blv, 4, #111, G-7. C. swanii (Fernald) Mackenzie. O, cd, 5b, #297, E-8. Cyperus filicinus Vahl. C, s, 6a2, #888, L-10. C. iria L. C, hj, 7, #939, G-6. C. lancastriensis Porter. U, abegh, 6al, #619, K-8; #1375, F-7. C. pseudovegetus Steudel. C, ber, 4, #547, F-5. C. strigosus L. A, gj, 3a, #1505, G-7. Fimbrystylis autumnalis (L.) R. & S. A, gj, 4, #938, G-6. Scirpus atrovirens Willd. C, nrz, 5a, #529, D-6. S. cyperinus (L.) Kunth. A, belnr, 5a, #607, J-6. Cyperus compressus L. O, ael, 4, #1867, I-7. C. filiculmis Vahl. O, bh, 5a, #1217, K-6; #1860, I-7. *ARACEAE* Orontium aquaticum L. R, nq, 6a2, #1600, I-7. Symplocarpus foetidus (L.) Nuttall. U, iejn, 2, #1026, G-7. *LEMNACEAE* Lemna perpusilla Torrey. A, ijnp, 4, #479, G-6. Spirodela polyrrhiza (L.) Schleid. A, ijnp, 4, #1052, M-7. *PONTEDERIACEAE* Heteranthera reniformis R. & P. U, jk, 4, #1248, F-7. Pontederia cordata L. O, ijklnq, 5a, #415, G-4. *JUNCACEAE* Juncus canadensis J. Gay ex La Harpe. C, jnr, 5a, #332, K-8. J. effusus L. A, jn, 8, #1130, G-7. J. marginatus Rostk. A, legh, 5a, #618, K-8. J. platyphyllus (Wiegand) Fernald. O, el, 5a, #330, K-7. J. tenuis Willd. A, aegh, 3a, #441, F-3. Luzula bulbosa (Wood) Rydberg. C, ey, 5a, #101, G-6. L. echinata (Small) Hermann. O, e, 5a, #1180, G-7. *LILIACEAE* Camassia scilloides (Raf.) Cory. R, persisting, at vacant lot, Court House, 5a, #1609, G-7. Convallaria majalis var. majalis L. R, ck, 7, #1729, F-7. Erythronium americanum Ker. O, emnr, 5a, #1068, G-6. Fritillaria obliqua persisting, old farm yard, 7, #222, K-8. Hemerocallis fulva L. A, fyz, 7, #380, G-6. Lilium superbum L. R, enr, 5a, #1508, J-6. L. tigrinum Ker. R, nr escape, 7, #1833, G-7. Melanthium virginicum L. R, ln, 5a, #1297, G-7. Muscari racemosum (L.) Miller. O, hfy, 7, #1577, G-6. Northoscordum bivalve (L.) Britton. U, lg, 4, #905, L-10. Ornithogallum umbellatum L. C, ey, 7, #1107, F-7. Polygonatum biflorum (Walter) Ell. C, ae, 4, #257, G-6.

Smilacina racemosa (L.) Desf. A, beklz, 5a, #267, G-6. Smilax herbacea L. O, lenr, 5a, #1201A, J-6; #1663, G-7. S. hispida Muhl. C, ae, 5a, #985, G-6. S. rotundifolia L. A, ae, 5a, #994, G-7. Uvularia perfoliata L. O, bev, 5a, #1066, G-6. U. sessilifolia L. O, elr, 5a, #409, G-4. Yucca filamentosa L. O, hz, 6c, #419, K-7. *AMARYLLIDACEAE* Hypoxis hirsuta (L.) Colville. O, ekr, 5a, #314, #518, E-8. Narcissus poeticus L. O, fy, 7, #1615, G-6. N. pseudo-narcissus L. A, efly, 7, #997, G-7. *IRIDACEAE* Iris cristata Aiton. R, spreading from cultivation, er, 5a, #1603, G-7. I. virginica L. O, jnr, 6c, #1775, G-7. *ORCHIDACEAE* Aplectrum hyemale (Muhl. ex Willd.) Torrey. U, ev, 5a, #1007, G-7. Corallorhiza odontorhiza (Willd.) Nuttall. U, ev, 5a, #971, H-6; #954, G-6. Liparis lilifolia (L.) Richard. R, aev, 5a, #383, G-6. Orchis spectabilis L. U, ael, 5a, #641, G-7. Tipularia discolor (Pursh) Nuttall. A, aekv, 5a, #687, G-7; #710, J-6. *SALICACEAE* Populus alba L. O, ghkxz, 7, #1714, G-6. P. deltoides Marshall. O, rlz, 5a, #1827, J-9. Salix babylonica L. R, spreading along creek, 7, #1589, G-7. S. humilis Marshall. P. mr. 6b. #1731, F-7. S. nigra Marshall. A, nr, 5a, #1258A, F-7. *JUGLANDACEAE* Carya pallida (Ashe) Engler & Graebner. O, be, 6c, #1712, G-6. C. tomentosa (Poiret) Nuttall. C, be, 5a, #923, G-6. Juglans nigra L. C, ey, 5a, #1675, G-7. *FAGACEAE* Castanea pumila (L.) Miller. U, aekl, 5a, #1748, K-5. Quercus alba L. A, abekl, 5a, #921, G-6. Q. falcata var. falcata Michaux. C, ael, 5e, #1674, G-7. Q. falcata var. pagodaefolia Ell. C, eln, 5c, #1723, M-7. Q. lyrata Walter. R, eln, 5e, #1894, H-6. Q. marilandica Muenchh. O, bek, 5a, #1677, G-7. Q. michauxii Nuttall. O, aln, 5e, #1892, J-8. Q. phellos L. C, be, 5e, #253, G-6. Q. prinus L. U, bek, 5a, #1702, G-6. Q. rubra L. C, aev, 5a, #270, G-6. Q. stellata Wang. O, ae, 5a, #1759, K-5. *ULMACEAE* Ulmus americana L. O, avny, 5a, #996, G-7. U. rubra Muhl. O, be, 5a, #248, G-7. *MORACEAE* Morus alba L. U, fy, 7, #1815, G-7. M. rubra L. A, efy, 5a, #259, G-6. *URTICACEAE* Laportea canadensis (L.) Weddell. R, en, 5a, #1620, G-7. Boehmeria cylindrica (L.) Swartz. A, egln, 4, #675A, G-7. *SANTALACEAE* Comandra umbellata (L.) Nuttall. O, bdh, 3a, #1612, J-6. *ARISTOLOCHIACEAE* Aristolochia serpenteria L. U, aev, 5a, #1635, E-5. Asarum canadense L. C, lr, 5a, #1085, G-6. Hexastylis virginica (L.) Small. A, bde, 6c, #1553, F-6. *POLYGONACEAE* Fagopyrum esculentum Moench. R, yf, 7, #1745, K-6. Polygonum arifolium L. O, nr, 5a, #1410, G-6. P. aviculare L. C, yz, 7, #1222, G-7. P. convolvulus L. O, fghv, 7, #1925, G-7. P. erectum L. U, fz, 3b, #387, G-4. P. hydropiperoides Michaux. O, jr, 4, #1246, G-6. P. pensylvanicum L. C, gjz, 5a, #795, G-7. P. punctatum Ell. C, fnz, 4, #696, #1468, G-7. P. sagittatum L. O, nrz, 5a, #860, F-6. P. setaceum Baldwin ex Ell. U, nrz, 5e, #1397, G-6. Rumex conglomeratus Murray. O, fyz, 7, #1218, K-6. R. crispus L. O, fyz, 7, #288, J-5. R. pulcher L. O, fz, 6c, #1769, K-6. R. verticillatus L. A, nr, 5a, #428, G-7. Tovara virginiana (L.) Raf. C, ef, 2, #1396, G-6. *CHENOPODIACEAE* Chenopodium album L. A, fyz, 7, #683, G-7. C. ambrosioides L. O, fghy, 7, #1489, G-7. *AMARANTHACEAE* Amaranthus hybridus L. A, ryz, 7, #1427, G-7. *PHYTOLACACEAE* Phytolacca americana L. A, fghyz, 5a, #335, K-8. *AIZOACEAE* Mollugo verticillata L. C, fyz, 7, #476, L-8. *PORTULACACEAE* Claytonia virginica L. A,

aemnv, 5a, #106, G-7. Portulaca oleracea L. R, ckz, 7, #962, D-7. *CARYOPHYLLACEAE* Cerastium glomeratum Thuillier. U, fy, 5a, #1034, G-8. C. semidecandrum L. O, fygh, 7, # 375, G-6. Dianthus armeria L. C, fghyz, 7, #1804, E-5. Lychnis alba Miller. R, lz, 7, #1182, J-7. L. coronaria (L.) Desr. U, fghz, 7, #416, G-4. Saponaria officinalis L. A, lyz, 7, #433, F-3. Scleranthus anuus L. O, fyz, 7, #1578, G-6. Silene antirrhina L. R, fh, 4, #1672, G-6. S. stellata (L.) Aiton f. R, arlv, 5a, #1288, G-7. Sagina decumbens (Ell.) T. & G. O, fghz, 5a, #98, K-5. *CERATOPHYLLACEAE* Ceratophyllum demersum L. C, op, 8, #425, G-7. *RANUNCULACEAE* Anemone quinquefolia L. R, enq, 6b, #1584, E-5. A. virginiana L. O, aev, 5a, #461, G-6; #527, E-8. Caltha palustris L. O, nlr, 1, #1021, G-6. Clematis dioscoreifolia Levl. & Vaniot. C, fghz, 7, #789, G-7. C. virginiana L. U, egz, 5a, #788, #1895, G-7. Hepatica americana (DC.) Ker. A, bev, 5a, #1001, G-6. Ranunculus abortivus Poiret. C, ae, 3a, #91, J-5. R. bulbosus L. A, fghyz, 7, #1027, G-6; #95, J-5. R. parviflorus L. U, fghz, 7, #1684, I-5. R. pusillus Poiret. O, jnr, 3b, #1586, #1592, G-7. R. recurvatus Poiret. C, eghy, 5a, #1062, G-6. R. sardous Crantz. U, lz, 7, #1812, L-9. R. septentrionalis Poiret. C, nr, 5a, #1022, #1071, G-6. *BERBERIDACEAE* Podophyllum peltatum L. C, env, 5a, #262, G-6. *MENISPERMACEAE* Menispermum canadense L. C, elv, 5a, #368, G-6. *MAGNOLIACEAE* Liriodendron tulipifera L. A, e, 5a, #272, G-6. *CALYCANTHACEAE* Calycanthus floridus L. R, persisting cultivar, 6c, #1909, G-7. *LAURACEAE* Lindera benzoin (L.) Blume. A, aegr, 5a, #264, G-6. Persea palustris (Raf.) Sarg. R, enl, 5e, #1724, M-7. *PAPAVERACEAE* Sanguinaria canadensis L. O, ev, 5a, #1000, G-6. *BRASSICACEAE* Barbarea verna (Miller) Ascherson. A, fy, 7, #1580, G-6. B. vulgaris var. arcuata (Opiz) Fries. R, fh, 7, #1693, J-6. Brassica napus L. O, fghy, 7, #1023, G-7. Capsella bursa-pastoris (L.) Medicus. O, fz, 7, #1594, K-6. Cardamine bulbosa (Schreber) BSP. O, aen, 5a, #1601, I-7. C. concatenata (Michaux) Ahles. C, enr, 5a, #1024, G-6. C. douglassii (Torrey) Britton. U, lnr, 6b, #1040, J-7; #1554, E-5. C. pensylvanica Muhl. O, rlnm, 3a, #1565, F-7. Draba verna L. C, fz, 7, #1581, G-6. Erysimum repandum L. R, y, 7, #1744, K-6. Hesperis matronalis L. O, fy, 7, #475, G-6. Lepidium virginicum L. A, fyz, 3a, #289-a, J-5. Nasturtium officinale R. Brown. O, joz, 7, #1091, G-6. Raphanus raphanistrum L. O, fy, 7, #819, G-7. Rorippa islandica (Oeder) Borbas. R, lr, 1, #1780, G-7. Sisymbrium officinalis var. leiocarpum DC. R, jr, 7, #1221, G-7. *CRASSULACEAE* Penthorum sedoides L. O, inrz, 5a, #1243, G-6. Sedum sarmentosum Bunge. R, marl spillway, 7, #1694, G-7. S. ternatum Michaux. R, wy (Ware Church), 5a, #579, G-7. *SAXIFRAGACEAE* Philadelphus inodorus L. R, e, 6c, #1670. *HAMAMELIDACEAE* Liquidambar styraciflua L. A, aegry, 4, #275, G-6. *PLATANACEAE* Platanus occidentalis L. C, bey, 5a, #271, G-6. *ROSACEAE* Agrimonia parviflora Aiton. O, eg, 4, #685, G-7. A. rostellata Wallroth. O, ev, 5a, #715, J-6. Alchemilla microcarpa Boissier & Reuter. R, pasture, lane campground, 7, #1685, I-5. Amelanchier arborea (Michaux f.) Fernald. C, eyz, 5a, #1734, F-7. Duchesnea indica (Andrz.) Focke. A, egyz, 7, #1028, G-6. Fragaria virginiana Duchesne. O, ev, 5a, #1063, G-6. Geum virginianum L. C, egy, 5b, #377, G-6. Potentilla canadensis L. C, egy, 5a, #1038, D-7. P. recta L. U, le, 7, #1300, G-7.

P. simplex Michaux. C, fz, 5a, #241, G-6; #1106, F-7. Prunus avium L. R, fyz, 7, #1563, K-6. P. persica (L.) Batsch. R, fy, 7, #1550, G-5. P. serotina Ehrhart. A, efy, 4, #1126, L-9. Rosa carolina L. O, eghz, 5a, #1802, E-5. R. multiflora Thunberg. A, fgyz, 7, #1179A, G-7. R. palustris Marshall. A, nr, 5a, #1220, G-7. R. wichuriana Crepin. U, yz, 7, #1747, J-5. Rubus cuneifolius Pursh. O, eg, 6a2, #1179, G-7. R. flagellaris Willd. C, cekl, 5a, #1083, G-6. R. occidentalis L. A, fghyz, 5a, #1123, G-7. Spiraea prunifolia Sieb. & Zucc. R, xz, 7, #1588, G-7. *FABACEAE* Albizia julibrissin Durazzini. C, erz, 7, #439, K-6. Amphicarpa bracteata (L.) Fernald. #1293. Baptisia tinctoria (L.) R. Brown. O, ef, 5a, #1805, E-5. Cassia fasciculata Michaux. A, ghz, 5a, #587, J-7. C. nictitans L. A, ghz, 5a, #633, E-9. Cercis canadensis L. C, ervz, 4, #274, G-6. Crotolaria sagittalis L. U, fh, 5a, #851, F-6. Cytissus scoparius (L.) Link. R, z, 7, #1081, G-6. Desmodium glutinosum (Muhl. ex Willd.) Wood. O, be, 4, #462, G-6. D. nudiflorum (L.) DC. C, abe, 5a, #718, G-7. D. obtusum (Muhl. ex Willd.) DC. O, bez, 5e, #847, F-6. D. paniculatum (L.) DC. C, hz, 5a, #1443, E-7. D. puaciflorum (Nuttall) DC. C, eh, 5a, #643, G-7. D. rotundifolium DC. C, bez, 5a, #1704. D. viridiflorum (L.) DC. C, befh, 5a, #802, G-7. Galactia regularis (L.) BSP. U, bh, 5a, #520, E-8. Glycine max (L.) Merrill. O, f, 7, #1908, K-6. Lathyrus hirsutus L. O, hz, 7, #1728A, G-6. L. latifolius L. C, bez, 7, #421, G-7. Lespedeza bicolor (L.) Barton. O, fghz, 7, #653, G-7. L. capitata Michaux. O, fghz, 5a, #912A, L-10. L. cuneata (Dumont) G. Don. C, fghz, 7, #790, G-7. L. procumbens Michaux. O, fghz, 5a, #800, K-7. L. striata (Thunberg) H. & A. O, fgh, 7, #775, K-7. L. stuevei Nuttall. O, fghz, 5e, #791, G-7. L. virginica (L.) Britton. O, hz, 5a, #1444. Lupinus perennis L. R, Woods Cross Roads (SE), 5a, #1604, E-5. Medicago lupulina L. A, fghz, 7, #358, G-6. Melilotus alba Desr. C, fghz, 7, #472, G-6. M. officinalis (L.) Lam. C, fghz, 7, #1166A, H-7. Psoralea psoraleoides (Walter) Cory. O, ef, 6a2, #509, G-7. Pueraria lobata (Willd.) Ohwi. U, efz, 7, #1530, G-6. Rhynchosia difformis (Ell.) DC. R, hz, 6c, #1818, K-5. Robinia pseudo-acacia L. A, efghyz, 5a, #1608, K-6. Strophostyles umbellata (Muhl. ex Willd.) Britton. O, gh, 5e, #1407, H-7. Stylosanthes biflora (L.) BSP. U, fh, 5a, #556, E-9. Tephrosia spicata (Walter) T. & G. O, ghz, 5e, #1837, #1910, G-7. Trifolium arvense L. A, hyz, 7, #386, G-4. T. dubium Sibthorp. O, gh, 7, #1736, F-7. T. hybridum L. O, gh, 7, #1285, H-7. T. incarnatum L. O, fyz, 7, #1115, G-8. T. pratense L. C, fghyz, 7, #896, L-10. T. repens L. C, fghyz, 7, #360, G-6, #1414, F-7. Vicia angustifolia Reichard. O, fgh, 7, #1616, G-6. V. dasycarpa Tenore. C, ghz, 7, #363, G-6. V. hirsuta (L.) S. F. Gray. O, ef, 7, #113, G-6. Wisteria sinensis (Sims) Sweet. O, efhz, 7, #1593, G-6. *LINACEAE* Linum medium var. texensis (Planch.) Fernald. O, kde, 5e, #384, G-6. L. usitatissimum L. R, fy, 7, #1743, K-6. L. virginianum L. C, gz, 5a, #582, E-8; #1318, C-5. *OXALIDACEAE* Oxalis dillenii Jacquin. O, ae, 4, #964, D-7; #1536, G-7. O. florida var. filipes (Small) Ahles. O, fy, 6al, #373, G-6; #1323. O. rubra St. Hil. O, yz, 7, #1058, G-7. O. stricta L. C, fyz, 4, #1256, F-7; #1495, G-6; #396, G-4. *GERANIACEAE* Erodium cicutarium (L.) L'Her. R, fy, 7, #1574, G-6. Geranium molle L. O, fyz,

7, #1650, G-7; #351, G-6. *POLYGALACEAE* Polygala incarnata L. O, hz, 5a, #552, E-9; #678, G-7. P. lutea L. U, gj, 6a2, #497, E-7. P. mariana Miller. C, fghyz, 5e, #673, #656, G-7. *EUPHORBIACEAE* Acalypha gracilens Gray. C, egh, 5a, #621, K-8. A. rhomboidea Raf. C, fgh, 5a, #833, G-7. Croton glandulosus var. septentrionalis Muell-Arg. O, fhgz, 5a, #1824, G-7. Euphorbia cyparissias L. O, fxz, 7, #1640, G-6. E. helioscopia L. R, fx, 7, #1579, G-6. E. maculata L. A, fghyzx, 4, #1424, G-7. E. marginata Pursh. R, adventive, 5a, #1295, G-7. E. supina Raf. C, fghxz, 5a, #1643, G-7. *CALLITRICHACEAE* Callitriche heterophylla Pursh. C, nopq, 5a, #1162, F-7. *ANACARDIACEAE* Rhus glabra L. C, fghyzx, 4, #482, J-5. R. radicans L. A, throughout, 4, #487, J-5; #1761, K-5. *AQUIFOLIACEAE* Ilex decidua Walter. R, aev, 5e, #1711, G-6. I. opaca Aiton. A, ehyx, 5a, #250, G-6. *CELASTRACEAE* Euonymus americanus L. C, elr, 5a, #269, G-6. *ACERACEAE* Acer platanoides L. R, yx, 7, #45, K-6; #1072, G-7. *RHAMNACEAE* Ceanothus americanus L. R, x, 5a, #1901, G-7. *VITACEAE* Parthenocissus quinquefolia (L.) Planchon. A, aeyxz, 4, #558, F-9; #252, G-7. Vitis aestivalis Michaux. C, ghx, 5a, #1673, G-7. V. labrusca L. O, eghx, 6al, #1678, F-7. *MALVACEAE* Hibiscus syriacus L. O, evxzy, 7, #724, G-6. Kosteletskya virginica (L.) Presl. C, qs, 5e, #761, K-7. Sida spinosa L. R, lqz, 7, #1907, K-6. *HYPERICACEAE* Hypericum gentianoides (L.) BSP. A, hx, 5a, #836, F-5; #936, G-6. H. gymnanthum Engelm. & Gray. C, gjrz, 5e, #346, K-8; other #'s 765, 1276, 1514. H. perforatum L. O, xz, 7, #400, G-4; #438-a, I-6. H. punctatum Lam. O, rzg, 5a, #730, G-6. H. stans (Michaux) P. Adams & Robson. R, cjkz, 5e, #1432, E-7. H. walteri Gmelin. U, inr, 5e, #1412, F-7. *CISTACEAE* Lechea racemulosa Michaux. C, hx, 5a, #1446, F-7. *VIOLACEAE* Viola brittoniana Pollard. U, cdelz, 6a2, #1131, J-6. V. conspersa Reichenbach. R, ekm, 6b, #1134, F-7. V. cucullata Aiton. C, anrv, 6b, #1567, F-7; #1093, G-7. V. emarginata var. acutiloba Brainard. O, bhe, 5a, #1133, I-7; other #'s 1199, 1568. V. papilionacea Pursh. A, ghyz, #104, G-7. V. primulifolia L. C, ehz, 5a, #1132, I-7; #1077, G-7. *PASSIFLORACEAE* Passiflora lutea L. O, ex, 5a, #644, G-7. *CACTACEAE* Opuntia compressa (Salisbury) Macbride. O, deh, 5a, #414, G-4. *ELEAGNACEAE* Eleagnus umbellata Thunberg. O, xz, 7, #1903, K-6. *LYTHRACEAE* Decodon verticillatus (L.) Ell. O, npr, 5a, #1849, I-7. Lythrum salicaria L. R, ehv, 7, #1286, G-7. *MELASTOMATACEAE* Rhexia mariana L. A, ghxz, 5e, #1433, E-7. *ONAGRACEAE* Oenothera biennis L. C, hx, 5e, #854, F-6. O. laciniata Hill. C, fghz, 4, #321, K-6. O. parviflora L. U, hzx, 6b, #1371, G-6. *HALORAGACEAE* Proserpinaca palustris L. O, jiop, 4, #1462, G-7. *ARALIACEAE* Aralia spinosa L. A, aevr, 5a, #774, K-7. *APIACEAE* Angelica venenosa (Greenway) Fernald. C, hx, 5a, #514, E-8. Chaerophyllum tainturieri Hooker. U, gxz, 5c, #1602, K-6. Cryptotaenia canadensis (L.) DC. A, e, 5a, #686, G-7. Foeniculum vulgare Miller. C, ghx, 7, #904, L-10. Hydrocotyle verticillata var. triradiata (A. Richard) Fernald. C, ijn, 4, #1210, G-7. Oxypolis rigidior (L.) Raf. O, beinr, 5a, #573, E-8. Ptilimnium capillaceum (Michaux) Raf. R, ij, 5e, #1262, G-6. Sanicula canadensis L. A, eghx, 5a, #333, G-7; also #'s 716, 768. S. gregaria Bicknell. O, aer, 5d, #1079, G-7; #1631, F-7. *NYSSACEAE* Nyssa sylvatica Marshall. O, begrxz,

5a, #654, J-6; #1781, G-7. *CLETHRACEAE* Clethra alnifolia L. A, grz, 5a, #494, G-7. *ERICACEAE* Chimaphila maculata (L.) Pursh. C, bed, 6al, #744, G-7. Gaylussacia frondosa (L.) T. & G. A, aec, 5a, #1121, G-7. Monotropa hypopithys L. R, dk, 4, #1145A, F-7; #1259, G-6. M. uniflora L. O, ae, 2, #408, G-4. Oxydendrum arboreum (L.) DC. C, aev, 5a, #583, E-8. Vaccinium vacillans Torrey. C, bde, 5a, #1638, F-5. *PRIMULACEAE* Lysimachia nummularia L. R, ijr, 7, #1197, G-7. L. quadrifolia L. U, glz, 5a, #1814, L-9. *PLUMBAGINACEAE* Limonium carolinianum (Walter) Britton. C, st, 4, #915, L-10. *EBENACEAE* Diospyros virginiana L. O, eru, 5a, #279, J-6. *OLEACEAE* Fraxinus americana L. O, evr, 5a, #1657, G-7. F. pennsylvanica Marshall. C, aenv, 5a, #422, G-7. Ligustrum ovalifolium Hasskarl. O, ghx, 7, #278, J-6. L. sinense Lour. O, eglry, 7, #590, G-9. *LOGANIACEAE* Cynoctonum mitreola (L.) Britton. U, ae, 4, #508, D-7. Gelsemium sempervirens (L.) Aiton. U, eyz, 5e, #1056, K-8. *GENTIANACEAE* Bartonia virginica (L.) BSP. U, aek, 5a, #600, F-5. Gentiana catesbaei Walter. R, cjkrz, 5a, #1538, F-7. G. saponaria L. R, cjkrz, 6al, #1543, F-7. Obolaria virginica L. U, aevk, 5a, #1016, G-6. *APOCYNACEAE* Apocynum cannibinum L. A, grlx, 3a, #442, F-3. Vinca major L. O, spreading, 7, #22, J-5. V. minor L. O, spreading, 7, #23, J-5. *ASCLEPIADACEAE* Asclepias amplexicaulis Smith. R, x, 5a, #1803, E-5. A. incarnata L. A, jrn, 5a, #794, G-7. A. syriaca L. C, ghxz, 5a, #577, E-9. A. tuberosa L. U, bdkxz, 4, #378, G-6. A. variegata L. U, delz, 5a, #1750, K-5. Matelea carolinensis (Jacquin) Woodson. R, z (spillway), 6c, #393, G-4. M. suberosa (L.) Shinners. O, acenl, 6c, #486, J-5; #555, E-9. *CONVOLVULACEAE* Cuscuta compacta Jussieu. C, ghxz, 5a, #1528, F-6. C. pentagona Engelm. C, gjxz, 4, #436, G-7; #1212, K-6. Ipomoea coccinea L. O, fghx, 4, #820, G-7. I. hederacea (L.) Jacquin. A, fghx, 7, #1216, K-6. I. lacunosa L. O, fhgxz, 5a, #892, L-9. I. purpurea (L.) Roth. A, ghx, 7, #1486, K-6. *POLEMONIACEAE* Phlox paniculata L. U, xz, 5a, #1226, G-7; #626, K-8. *BORAGINACEAE* Cynoglossum virginianum L. U, aevr, 5a, #1633, G-7. Myosotis arvensis (L.) Hill. O, eghx, 7, #21, J-7. M. laxa Lehmann. O, jnr, 3b, #1659, G-7. M. macrosperma Engelm. C, aev, 5a, #1623, G-7. *VERBENACEAE* Verbena simplex Lehmann. O, ghyxz, 5a, #614, K-8. *PHRYMACEAE* Phryma leptostachya L. C, eghyx, 2, #463, G-6. *LAMIACEAE* Glecoma hederacea L. C, ghyx, 7, #1078, #1559, G-7. Mentha piperita L. O, xz, 7, #1257, F-7. Monarda punctata L. U, hx, 5a, #1365, G-6. Lamium amplexicaule L. A, fyxz, 7, #'s 14, 15, 19, K-6. L. purpureum L. A, fyx, 7, #5, K-6. Perilla frutescens (L.) Britton. C, ghx, 7, #834, G-7. Prunella vulgaris L. C, eghyxz, 1, #434, F-3. Pycnanthemum incanum (L.) Michaux. O, e, 5a, #1853, I-7. P. tenuifolium Schrader. U, bde, 5a, #532, D-7. *Salvia pratensis L. R, fz, 7, #1900, G-7. Satureja calamintha var. nepeta (L.) Briquet. A, fghyx, 7, #446, F-3. Scutellaria elliptica Muhl. C, hxz, 5a, #352, G-7. S. lateriflora L. O, ijn, 3a, #1252, F-7. Stachys hyssopifolia Michaux. O, ghx, 6a2, #1279, H-7. Trichostema dichotomum L. O, ghx, 5a, #846, F-6. *SOLANACEAE* Datura stramonium L. C, fghyxz, 7, #1215, G-7. Physalis heterophylla Nees. R, elz, 5a, #1751, K-5. P. virginiana Miller. R, fx, 5a, #990, J-5. Solanum carolinense L. A, fghyxz, 5a, #282, J-5. *SCROPHULARIACEAE* Chelone obliqua L. U, nr, 6al, #850,

F-6. Gratiola neglecta Torrey. C, gj, 5b, #1055, K-8; also #'s 1189, 1198A. G. pilosa Michaux. C, hxz, 5e, #1234, F-7; #1433A, E-7. G. virginiana L. C, agj, 5c, #1240,#1251, F-7. Kickxia elatine (L.) Dum. R, gl, 7, #611, K-8. Pedicularis canadensis L. R, er, 5a, #1287, G-7. Penstemon laevigatus Solander ex Aiton. R, gz, 7, #1776, G-7. Verbascum blattaria L. A, ghxz, 7, #246, G-7. V. thapsus L. O, ghxz, 7, #391, G-4; #478, G-6. Veronica arvensis L. C, ghyxz, 7, #1572, K-6; #1591, G-7. V. anagallis-aquatica L. O, ijn, 1, #348, G-6. V. officinalis L. C, ghxz, 7, #301, E-8; #1146, F-7. V. peregrina L. O, ghxz, 4, #1051, #1573, K-6. V. persica Poiret. O, fhyxz, 7, #1585, K-6. V. serpyllifolia L. R, gj, 7, #1613, G-6. *BIGNONIACEAE* Anisostichus capreolata (L.) Bureau. C, ae, 5a, #698, G-7. *OROBANCHACEAE* Epifagus virginiana (L.) Britton. A, beech woods, 5a, #953, G-6. *ACANTHACEAE* Ruellia caroliniensis (Walter) Steudel. O, ghxz, 5a, #553, F-9. *PLANTAGINACEAE* Plantago aristata Michaux. A, xz, 3a, #234, #436-a, G-6. P. lanceolata L. A, fghyxz, 7, #239, G-6. P. rugelii Dcne. O, ghxyz, 5a, #449, K-6. P. virginica L. C, fghyxz, 3a, #1096, G-7. *RUBIACEAE* Cephalanthus occidentalis L. C, nrz, 4, #525, G-7. Diodia teres Walter. A, ghxz, 5a, #453. G-6. Galium pilosum Aiton. C, beh, 5a, #1219, G-6. G. triflorum Michaux. O, ez, 1, #554, E-9. Houstonia purpurea L. C, hxz, 5a, #731, G-6; #1188, F-7. Sherardia arvensis L. U, hyz, 7, #1151, G-7. *CAPRIFOLIACEAE* Lonicera japonica Thunberg. A, throughout, 7, #237, G-6. L. sempervirens L. O, elz, 5e, #1128, G-7. Symphoricarpos orbiculatus Moench. O, aenl, 5a, #103, G-7. Viburnum prunifolium L. C, aer, 5a, #1060, G-6. *CUCURBITACEAE* Melothria pendula L. R, gpr, 4, #1519, J-6. *LOBELIACEAE* Lobelia siphilitica L. U, aeg, 5a, #807, G-7. Specularia perfoliata (L.) A. DC. A, x, 4, #1213, F-7. *ASTERACEAE* Ambrosia artemisiifolia L. A, ghyx, 4, #810, G-7. Antennaria plantaginifolia (L.) Richardson. C, beh, 5a, #1158, F-7. A. solitaria Rydberg. U, bev, 5a, #1582, G-6. Anthemis arvensis L. U, xz, 7, #1720, G-6. Arnica acaulis (Walter) BSP. R, xz, 6a, #1696, J-6. Aster gracilens Nuttall. U, aec, 6c, #809, G-7. A. lateriflorus (L.) Britton. C, ghx, 5a, #933, G-6. A. paternus Cronquist. O, bdh, 6al, #546, F-5. A. solidagineus Michaux. U, dhxz, 6b, #418, G-4. A. tenuifolius L. C, sgu, 6a2, #914, L-10. Bidens bipinnata L. A, xyz, 4, #826, G-7. B. frondosa L. C, gz, 3a, #943, G-6. B. laevis (L.) BSP. O, gjnrz, 4, #1918, G-7. B. tripartita L. O, nrpz, 7, #1497, G-6. Borrichia frutescens (L.) DC. C, su, 4, #457, L-10. Cacalia atriplicifolia L. C, ae, 5a, #650, G-7; #1636. Carduus discolor (Muhl. ex Willd.) Nuttall. O, xz, 5d, #749, K-8. C. nutans L. R, xz, 7, #512, F-8. C. spinosissimus Walter. O, xz, 5e, #1762, G-7. Centaurea cyanus L. U, ghxz, 7, #431, F-5. Chrysanthemum leucanthemum L. A, eghyxz, 7, #240, G-6. Cichorium intybus L. U, xz, 7, #437, J-6. Coreopsis lanceolata L. O, rz, 5a, #1183, J-6. C. tinctoria Nuttall. R, hx, 3b, #1268. Elephantopus carolinianus Willd. A, eghx, 4, #828, G-7. E. nudatus Gray. C, ae, 5e, #796, G-7. Erechtites hieracifolia (L.) Raf. C, efghx, 5a, #844, F-5. Erigeron annuus (L.) Persoon. O, ghx, 5a, #1273, G-6. E. canadensis var. canadensis L. A, ghxz, 4, #620, K-8. E. canadensis var. pusillus (Nuttall) Ahles. A, hxz, 4, #949, G-6. E. pulchellus Michaux. C, e, 5a, #1067, G-6. E.

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Aeronautics and Aerospace Science Section

THEORETICAL MODELS OF "STRESS DISSECTION" BY VOICE ANALYSIS FOR IMPROVEMENTS IN AERONAUTICS AND AEROSPACE SCIENCE. John C. Bartone, Brenda Reynolds and John Bartone, II. American Health Research Institute Ltd., Annandale, Virginia 22003.

The use of voice analysis is expanding in crime and pre-employment screening but remains largely unexplored in science, medicine and aeroscience.

The theory, practice and results of voice analysis are based primarily on autonomic superimposition of control upon voluntary laryngeal muscles resultant from forces known or unknown, real or otherwise, of stress. Validity, reliability and interpretation of stress (deception or "lies") is highly subjective to errors and therefore unreliable and unscientific. Many other factors worsen results. New theoretical models are presented which can further worsen results of voice analysis, or given consideration, with other psychodiagnostic evaluatives, can yield better stress dissection of human problems and job performances.

HOMOGENEOUS NUCLLATION OF NITROGEN AND ITS INFLUENCE ON AIRFOILS TESTED IN THE LANGLEY 0.3-M TRANSONIC CRYOGENIC TUNNEL. E. H. Dotson*, George Washington University, R. M. Hall, NASA-Langley Research Center, Hampton, Virginia 23665

A computer program utilizing a one-dimensional model is used for simulating flow over the supersonic region of an airfoil. The "classical theory" of homogeneous nucleation (Becker and Doering, Volmer, Frenkel, and others) and the droplet growth equation of Gyarmathy, which is valid for both free-molecular and continuous regimes, are used to introduce the condensation effects on the flow. The Beattie-Bridgeman equation of state is also used to show real gas effects. The results of the program are compared against experimental data taken in the Langley 0.3-m Transonic Cryogenic Tunnel. These comparisons are used to judge the accuracy of the various modifications to the classical nucleation equation (Lothe and Pound, Reiss, Kikuchi, and Feder) and to the surface tension (Tolman) of the droplets. The evaluation of the data and the program are done both above and below the triple point of nitrogen.

A LOW DAMPING, TWO-DEGREE-OF-FREEDOM FLUTTER MOUNT SYSTEM FOR TESTING RIGID WINGS AT DIFFERENT ANGLES OF ATTACK. M. G. Farmer, Aero-Space Technologist, Configuration Aeroelasticity Branch, Loads and Aeroelasticity Div., NASA Langley Research Center, Hampton, VA 23665

A wind-tunnel model mount system for conducting flutter research using a rigid wing has been developed. The wing is attached to a splitter plate so that the two move as one rigid body. The splitter plate is supported away from the tunnel wall by a system of rods with fixed-fixed end conditions. The rods flex in such a way that only pitch and plunge oscillations are permitted. At the tunnel wall the rods are attached to a remotely controlled (or controllable) turntable so that angle of attack can be varied. Wind-tunnel data obtained by using the mount system are presented for a supercritical and a conventional airfoil. Both classical flutter and stall flutter data are presented.

NEW APPLICATIONS OF THE NASA-VORTEX LATTICE METHOD (MARK IV VERSION). J. E. Lamar*, Transonic Aerodynamics Division, NASA, Hampton, VA 23665.

The Mark IV version of the NASA-Vortex Lattice Method had additional features not present in earlier editions. Among the features are the abilities (1) to handle up to four planforms and 400 lifting panels, (2) to calculate nearby flow-field properties associated with linear aerodynamics at a specified lift coefficient, (3) to determine the longitudinal load distribution, (4) to compute the vortex-flow aerodynamics on cambered configurations, (5) to specify the limits of the side-edge force as well as the already existing ability to specify them for the leading-edge force, and (6) to avoid the requirement that the outermost streamwise edge have a zero loading--this is important when only a portion of that edge satisfies the previous stipulation. Furthermore, there have been improvements in the manner in which the input data are provided to execute the program. Results typifying the above new features will be presented.

SPACE-BASED DIRECT SOLAR-PUMPED IODINE LASER. J. H. Lee,* Vanderbilt University, Nashville, TN 37235; and J. W. Wilson and N. W. Jalufka,* NASA Langley Research Center, Hampton, VA 23665

A direct solar-pumped laser (DSPL) with 1-kilowatt output is considered as an experimental prototype for a space-based high power DSPL systems. The DSPL system consists of a 30-meter diameter solar collector, a 1.5-meter laser cavity, and a gas handling/cooling unit. The laser cavity is tuned to the $\lambda = 1.315$ μm atomic iodine laser transition. Basic requirements for each system component are evaluated and methods of reducing such requirments are proposed. The efficiency, the mass, and the cost of the system are estimated and compared with those of an electric discharge CO_2 laser (EDL) system which is powered by solar photovoltaic electricity. Although the overall system efficiency of the DSPL system is apparently small, the unique characteristics of the iodine laser kinetics make it competitive with the projected high-efficiency EDL in mass and cost requirements. The packaging and the deployment of the proposed system for space experiments requires only simple and available technologies.

RIGID WAVY WALLS FOR TURBULENT VISCOUS DRAG REDUCTION. J. C. Lin and L. M. Weinstein*. Aerospace Engineers, Viscous Flow Branch, High-Speed Aerodynamics Division, NASA Langley Research Center, Hampton, VA 23665.

A wave-shaped surface corrugation with wavelength the order of the boundary layer thickness produces cyclical oscillations in pressure gradient and wall curvature, the net effect of which can be a reduction in turbulent skin friction. The present paper discusses low speed drag measurements over surfaces with transverse waves having both sinusoidal and non-sinusoidal wave form. Several of the non-sinusoidal geometries indicate significant reduction in the pressure drag which normally occurs on transverse wave trains such as ocean waves. Experimental and numerical computations indicate that wavy surfaces which produce a net reduction in total drag could probably be developed.

PROJECTED SiC/Ti COMPOSITE STRENGTHS BY FIBER COATING STUDIES. L. L. McDaniel*, W. D. Brewer*, and J. Unnam*. NASA-Langley Research Center, Hampton, Va. 23665

Silicon carbide reinforced titanium matrix composites are of interest for aerospace applications requiring high stiffness and strength at elevated temperatures. However, due to fiber/matrix interactions during composite consolidation these composites have often exhibited degraded mechanical properties. A new silicon carbide fiber, SCS-2, was recently developed with superior mechanical properties compared to previous SiC fibers, even after interaction with titanium. The SCS-2/Ti system, simulated by sputtering about 1 μm of Ti directly onto individual SCS-2 fibers, was investigated to characterize the microstructural and chemical interactions and the associated mechanical property changes. Because aluminum is known to decrease the interaction between SiC and Ti due to a rejection mechanism, a modified SCS-2/Ti system, with about 1 μm of Al in between SCS-2 and Ti, was also considered. Coated fibers, with and without Al, were subjected to temperatures typical of composite consolidation. Fiber tensile testing as well as metallurgical analyses including Auger spectroscopy, electron microprobe, and SEM were conducted. Experimental results and potential composite strengthening mechanisms will be discussed.

JUMP PHENOMENA OF SYMMETRICALLY LAMINATED COMPOSITE PLATES. C. Mei* and Habib Eslami*, Department of Mechanical Engineering and Mechanics, Old Dominion University, Norfolk, Va. 23508.

Large amplitude response of symmetrically laminated rectangular plates subjected to sinusoidal excitation is studied. Approximate solutions using Galerkin's approach for the nonlinear strain response of the clamped laminates are presented. Ritz method is then employed to solve the nonlinear modal equation. Comparisons are made between the experimental data and the analytical result.

LARGE DEFLECTION AND LARGE AMPLITUDE FLEXURAL VIBRATIONS OF ANGLE-PLY LAMINATED COMPOSITE PLATES. Chuh Mei* and Mo-How Shen*. Department of Mechanical Engineering and Mechanics, Old Dominion University, Norfolk, VA 23508.

Large deflection and large amplitude free and forced vibrations of antisymmetric, angle-ply, laminated, rectangular plates are studied analytically. The nonlinear equations of motion for angle-ply laminated plates are expressed in terms of a stress function F, and a lateral displacement w. A deflection function satisfying the out-of-plane boundary conditions and representative of the first mode is assumed. Corresponding to the assumed mode, a stress function satisfying the different inplane edge conditions is obtained by solving the compatibility equation. Galerkin's method is then applied to the governing equation of motion to yield a nonlinear time-differential equation. All simply supported and clamped edges with either immovable and movable inplane edges are considered. Static deflections, and nonlinear frequencies are then obtained for rectangular laminates of different length-to-width ratios, lamination angles, number of layers, and loadings. (Aided by AFOSR-80-0107)

A HYBRID APPROACH TO TRANSONIC VISCOUS FLOW WITH MODERATE TO STRONG SHOCK WAVE. Ram Bachan Ram of State Univ. of NY, Oneonta, NY and Airfoil Aerodynamics Branch, NASA-Langley Research Ctr., Hampton, VA 23665

The proposed hybrid method consists of a finite difference-relaxation technique for solving the overall transonic potential flowfield, the method of integral relations for obtaining the Euler solution in the shock region, and the integral method, extended to include flows with mass and heat transfer, for obtaining the boundary layer solution. Thus, the procedures developed independently for solving potential, inviscid, and viscous boundary layer flows are combined appropriately to enable an analysis of the viscous-inviscid interaction problem at transonic speeds. Both attached and separated boundary layers are considered for either weak or strong interactions. The system of resulting equations for inviscid and viscous flows are coupled by the streamline angle of the inviscid flow at the edge of the boundary layer and are integrated simultaneously for strong interactions. The weak interaction is accounted for by simply correcting the airfoil surface with the boundary layer displacement thickness. The essential feature of the full inviscid flow, ie., the effect of entropy change across the shock wave by a Rankine-Hugoniot jump, can be determined using potential flow properties as the initial and boundary conditions in the shock region.

ANALYSIS OF SLENDER WING CONFIGURATIONS WITH SEPARATED FLOWS USING FREE VORTEX SHEET METHOD. C. S. Reddy and F. Ghaffari*. Mechanical Engineering and Mechanics Dept., Old Dominion Univ., Norfolk, VA 23508.

The aerodynamic characteristics of highly sweptback wings with sharp leading edges and separation induced vortex flows have been investigated by the free vortex sheet method developed by Boeing Airplane Company under a contract with NASA Langley Research Center. The method is based on a three-dimensional inviscid flow model. It is an advanced panel method employing distributed doublet singularities located on the mean surface of wing and free vortex sheet, and is capable of computing forces, moments and surface pressures.

The models studied included an 80°/65° double delta, a 74°/65° double arrow and a 74° delta with 50 mm conical leading edge vortex flap deflected up or down. The longitudinal aerodynamic characteristics, spanwise pressure distributions and vortex sheet shapes have been estimated. The results predicted by the method have been compared with the existing data, wherever available, and found a fairly good agreement between them. Also, the effects of different types of modeling, such as single or multiple vortex systems on the leading edge and near wake or no near wake modeling, on the aerodynamic performance of wings have been studied. (Aided by NASA Grant NSG-1561)

U.S./U.S.S.R. MILITARY AIRCRAFT TRENDS. M. Leroy Spearman, Langley Research Center, Hampton, Va. 23665.

The trends in military aircraft design and development since World War II will be traced for both the U.S. and the U.S.S.R. These trends reflect the science and technology advancements of the two countries and indicate the extent to which basic research and development matures into applied military aircraft systems. The trends can also be interpreted as an indication of anticipated military needs relative to the national interest. Some effects of technology transfer are evident in some systems. However, in other cases, distinctively innovative design features are developed for specific purposes. A review of the trends indicate some basic design philosophy and reveal some fundamental differences in military aircraft development between the two countries.

Agricultural Sciences Section

RATE OF PASSAGE OF DIGESTA IN GROWING SWINE AS AFFECTED BY CRUDE FIBER LEVELS AND VIRGINIAMYCIN SUPPLEMENTATION. C. Austin*, V. Ravindran and E. T. Kornegay. Dept. of Animal Science, VPI & SU, Blacksburg, Va. 24061

Five separate studies, involving three groups of twelve pigs each, were conducted to study the influence of crude fiber and virginiamycin on digesta rate of passage (RP) in growing swine. Two levels (3.2 and 7.3%) of crude fiber and two levels (0 and 11 ppm) of virginiamycin were used in a 2 x 2 factorial arrangement of treatments. The high fiber diet was formulated using 50% ground oats. All diets were isonitrogenous and isocaloric. Pigs were fed 1400 g daily in two equal feedings. RP was measured by adding 0.5% chromic oxide to the diets and observing the time taken for the first appearance of marker in the feces. The high fiber diet had a faster ($P<.05$) RP (21.7 vs 26.4 hr). Virginiamycin supplementation slowed ($P<.01$) the RP of both low (29.4 vs 23.2 hr) and high (25.3 vs 18.1 hr) fiber diets. Another trial conducted to study the rate of disappearance of chromic oxide following withdrawal from the diets showed similar results.

CORN AND SOYBEAN NEMATODE SURVEY RESULTS, 1981. D. E. Babineau. Dept. of Plant Pathology & Physiology. Va. Tech. Eastern Va. Res. Station, Warsaw, VA 22572.

A plant-parasitic nematode survey was conducted during the fall of 1981 in five counties in the Northern Neck region of Virginia. Samples for nematode assay were collected in October from 48 corn fields and in December from 61 soybean fields. Nematodes were extracted by the elutriation-centrifugation method. Nematode populations which may cause crop damage if growing conditions are unfavorable were found in 25% of the corn fields and 23% of the soybean fields. An additional 7% of the corn fields and 14% of the soybean fields had infestations which will probably cause crop damage and a nematode management program should be profitable. These predictions are based on nematode threshold densities for the crop to be grown in 1982. Lance (Hoplolaimus spp.) was the most frequently found nematode at problem levels. Next in occurrence were lesion (Pratylenchus spp.) and root-knot (Meloidogyne spp.) nematodes. Other genera identified at potentially damaging populations were stunt (Tylenchorhynchus spp.), spiral (Helicotylenchus spp.) and dagger (Xiphinema spp.).

A predictive nematode survey of crop land is a technique which can identify this yield reducing agent and thus provide data to aid in farm management decision making.

FLEXURAL STRENGTH OF OTTER LIMB BONE. J. L. Baker* and J. H. Wilson*. Dept. of Agricultural Engineering, and P. F. Scanlon, Dept. of Fisheries and Wildlife, Va. Polytechnic Inst. and State Univ., Blacksburg, Va. 24061.

The otter is an important furbearing resource in Virginia and since 1974 the number of tagged otter pelts indicates a greater demand for otter as a fur resource. In Virginia, there is little information on current otter population characteristics. A wide array of data including population structures, bone strength characteristics and reproduction rates are necessary for making sound management decisions to ensure the maintenance of otter populations consistent with both consumptive and non-consumptive demands upon this furbearing resource.

The objective of this investigation was to provide data relative to the mechanical properties of otter limb bones. The experimental program consisted of three series of three-point bending tests. In the first series (radius, ulna, tibia and radius) specimen beam lengths were 38 mm. In the second series (radius and ulna) beam length was 25.4 mm and in the third series (tibia and fibula) beam length was 50.8 mm. The modulus of elasticity was determined from the bending tests and the results are 13.1 GPa, 14.1 GPa, 13.9 GPa and 15.2 GPa respectively for the radius, ulna, tibia and fibula.

TECHNIQUES FOR EVALUATING FLEXURAL STRENGTH OF ANIMAL BONE. J. L. Baker* and J. H. Wilson*. Dept. of Agricultural Engineering, Va. Polytechnic Inst. and State Univ., Blacksburg, Va. 24061.

A common test used in the evaluation of the mechanical properties of bone has been the simply supported beam with a center load in simple bending. In the evaluation of force-deformation data from this simple three-point bending test, the common assumption has been that bending accounted for the deflection and shear deflection was ignored. This assumption is only valid when the length to diameter ratio is greater than ten. For many bone specimens the L/D ratio is less than ten and shear must be included in the deflection of the specimen.

Techniques have been developed to determine the effects of shear on the bending deflection of animal bone. These techniques include the 3-point bending test, 4-point bending test and the evaluation of the shear form factors that are needed to determine the shear component of deflection. Shear form factors are dependent on cross sectional geometry and these factors were determined by machining specimens from aluminum with shapes common to animal bones. With the shear form factor evaluated, the shear component of deflection can be determined. Analysis then yields the shear modulus and young's modulus.

INHERITANCE OF BODY WEIGHT AND RELATED TRAITS IN CHICKENS. G. F. Barbato, P. B. Siegel and J. A. Cherry. Virginia Tech, Blacksburg, VA 24061.

The genetical architecture of body weight in two lines of chickens divergently selected for high and low juvenile body weight was principally additive. Early feed intake was influenced by potence in the direction of the high-weight line, while early water intake was similar among all populations. Heterosis was observed for feed efficiency, associated with an equivalent negative heterosis for percentage carcass fat. It was hypothesized that different genetic systems exist for the phenotypic expression of high and low body weight, and may be applied to the genetic improvement of feed efficiency and carcass composition.

A TECHNIQUE FOR DETERMINING THE REPRODUCTIVE STATUS OF GRASSHOPPERS IN VIRGINIA PASTURES. R. G. Bellinger* and R. L. Pienkowski. Dept. of Entomology, VPI&SU, Blacksburg, VA 24061

A dissection technique was used to determine the reproductive status and history of female Melanoplus femurrubrum (DeG.) and Encoptolophus sordidus (Burm.) collected from pastures in Virginia in 1981. This technique has not been previously used to determine the reproductive history of North American species. The technique entails dissecting ovaries from fresh females, and examining them under saline. Independent counts were made of the number of ovarioles, terminal oocytes, copora lutea, resorption bodies, and eggs in the oviducts. The technique allows for determination of reproductive history of individual females in that the number of pods laid and the number of eggs in each pod can be determined without direct observation of the pods. Information was obtained on up to 3 previously laid pods, and 2 potential pods (eggs in the oviducts and the terminal oocytes). Individuals of species examined laid fewer pods in the field than expected, and the inter-pod period was longer. The effects of nutritional and environmental factors, parasitization, etc. on reproduction can now be determined. Observations are easily made, but material must be live and fresh to obtain accurate and useful information.

EX-VESSEL DEMAND FOR HARD BLUE CRABS IN THE CHESAPEAKE BAY. O. Capps, Jr.* Dept. of Agricultural Economics, Va. Polytechnic Inst. and State University, Blacksburg, VA. 24061

Factors hypothesized to influence the monthly ex-vessel price of hard blue crabs in the Chesapeake Bay from 1973 to 1980 were investigated. Season of landings, total landings, and the wholesale price of hard blue crabs had significant impacts on the ex-vessel price. Landings of hard blue crabs in the South Atlantic and the Gulf were not statistically significant. On the basis of the estimated flexibility coefficients, total revenue to harvesters could be increased by increasing landings in the Chesapeake Bay throughout each season of the year.

MATE SELECTION IN JAPANESE QUAIL: EFFECT OF PLUMAGE COLORATION. C. C. Blohowiak and P. B. Siegel. Virginia Tech, Blacksburg, VA 24061.

The objective of this study was to observe factors involved in mate selection by male Japanese quail. The quail used in this experiment were obtained from a randombred population in which there was segregation for the plumage mutants redhead and albino, in addition to wildtype. Six groups, determining early experience, were hatched and maintained in visual isolation from each other. These flocks included experiences where either the three plumage colors were raised separately or where two plumage colors were raised together. Mating trials were conducted for evidence of male preference for hen plumage color when a simultaneous choice was not available. The cumulative number of completed matings over three 8-minute trials with each hen plumage color served as the measurement of preference. There were no significant differences among male plumage colors for their frequency of mating. The manner in which the males were raised (plumage colors separate or intermingled), while significant, varied among male morphotypes. A majority of the males preferred wildtype and redhead hens over albinos regardless of how they were reared. There was no discrimination between wildtypes and redheads. The results are discussed in the context of genetic components, sexual imprinting and learning experiences.

G-C PROFILES TO CHARACTERIZE BEEF FLAVOR. K. P. Bovard, I-Tsuen Chen, and P. P. Graham. Dept. of Animal Science and Dept. of Food Science and Technology, Va. Polytechnic Inst., Blacksburg, Va. 24061

Gas chromatograms of head space volatiles were obtained from 89 samples of broiled beef, 79 of which came from steers in a study of seven forage-feeding systems, and ten of which served as positive controls, from conventionally grain-fed steers. For each chromatogram, a series of 44 separate peaks was evaluated using peak height and area. Differences in levels of grain feeding among the seven forage systems were associated with differences in G-C profile data. Certain peaks were nearly always present in G-C profiles of beef from steers fed forage only, and absent from profiles of the grain-fed positive controls. For other peaks, the converse was true. Peaks showing differences of this kind, most clearly associated with differences in levels of forage feeding, were combined in a series of multiple regression analyses to provide objective predictions of beef flavor that were highly correlated ($P < .01$) with conventional sensory evaluations by taste panel. This technique offers a simple cheap method of objective evaluation of beef flavor far less costly than that of conventional sensory panels.

THE INFLUENCE OF BIOTIN INJECTION ON THE UPTAKE AND CLEARANCE OF BIOTIN IN PIG PLASMA. K. L. Bryant*, E. T. Kornegay, J. W. Knight, H. S. Bartlett* and D. R. Notter, Dept. of Animal Science, VPI & SU, Blacksburg, Va. 24061

Nine crossbred gilts, surgically fitted with indwelling anterior vena cava cannulae were randomly assigned to receive either a sham (S), 2.2 ug/kg (L) or 6.6 ug/kg (H) biotin injection. Following adjustment to surgery, females received their respective injection intramuscularly. Plasma biotin concentrations (PBC) were determined from blood samples taken at 39 time points during a 3-day period following injection. All females were housed and fed (2 times/day) in a similar manner. There were no time differences ($P > .05$) in PBC for the sham injected gilts suggesting no diurnal variation in PBC. The S injected pigs had an overall mean PBC of 42.5 ng/dl. PBC increased and peaked at 4 hr (66.7 ng/dl) and 6 hr (90.9 ng/dl) following biotin injection, L and H respectively. These rises in PBC for L and H injections resulted in treatment differences ($P < .05$) in PBC from 4 hrs to 12 hrs post-injection. Uptake and clearance rates were calculated from the data using exponential curves. The uptake rates (% increase PBC/hr) for L and H were 16.5 and 15.9, respectively. Clearance rates (% decrease PBC/hr) for L and H were 5.7 and 2.8, respectively.

ATTIC SOLAR COLLECTORS FOR CROP DRYING. C.L. Butts*, D.H. Vaughan, and J.L. Baker*, Dept. of Agricultural Engineering, Va. Polytechnic Inst. and State Univ., Blacksburg, VA 24061.

Covered plate attic solar collectors were constructed on Virginia farms, one located near Axton and the other near Bremo Bluff. Each collector was built as an integral part of the attic of a machine shop building and was located near present on-farm grain drying facilities. Translucent greenhouse grade fiberglass was used as the roofing material. At Axton, light green fiberglass was used on both roof slopes of the southeast-facing building. At the second location green fiberglass was used on the south-facing slope and white fiberglass was used on the north-facing slope of the building. The buildings were built using conventional building practices with the trusses, roof purlins and plywood in the ceilings being painted with flat black paint to provide the absorber surface area. The buildings were connected to the grain bins by ducting constructed from exterior plywood.

Temperature rises of air flowing through the attics were monitored and performance criteria were evaluated with respect to the solar energy available. The collector efficiencies for the two buildings both averaged approximately 50% for the 1980 drying season, and depended upon environmental parameters.

COMPARISON OF SAMPLING TECHNIQUES FOR THISTLE INSECTS. B. Cartwright* and L. T. Kok, Dept. of Entomology, Va. Polytechnic Inst. & State Univ., Blacksburg, VA 24061

Tests were conducted in 1980 and 1981 to compare the efficiency of three sampling techniques for 3 biological control agents of Carduus thistles, Rhinocyllus conicus (Froelich), Trichosirocalus horridus (Panzer) and Cassida rubiginosa Muller. Release-recapture tests with a D-vac® suction apparatus showed that a 3 second suction removed as many adult insects of each species from thistle rosettes as did 15 or 30 second suctions. Similar tests between grazed and ungrazed habitats indicated that a significantly greater percentage of R. conicus was removed in an ungrazed habitat compared to a grazed habitat. However, no differences were found between habitats for T. horridus and C. rubiginosa. Use of a reduced suction orifice resulted in increased air flow and improved recovery. Release-recapture tests on thistle rosettes showed that collection of each insect declined as density increased. Field comparisons of visual counts, a jarring technique and suction sampling showed visual counts to be most accurate for estimating densities but also most time consuming. The suction technique appears to be the least accurate but most time-efficient. Jarring is intermediate with regard to accuracy and time but is not suitable for thistle rosettes.

VARIETAL PREFERENCES OF PIERIS RAPAE AND TRICHOPLUSIA NI ON CABBAGE IN SOUTHWESTERN VIRGINIA. J. R. Chamberlin* and L. T. Kok. Dept. of Entomology, VPI & SU, Blacksburg, VA 24061

A field study on the varietal preferences of Pieris rapae (the imported cabbageworm) and Trichoplusia ni (the cabbage looper) on cabbage in Montgomery Co., VA was conducted during the summer of 1981. Eggs, small larvae, large larvae and pupae of both insect species per cabbage variety were counted weekly. Seasonal egg counts on each variety were compared to determine ovipositional preference. The ratio of eggs to large larvae was similarly compared to detect antibiosis. Each variety was harvested at maturity, weighed and assigned a damage rating from 1-5. Red Acre was the least attractive, and Rio Verde the most attractive, variety for oviposition by Pieris rapae. Antibiosis was strongly indicated by Rio Verde and Green Winter. Trichoplusia ni populations were low; oviposition appeared to be lowest on Red Acre and highest on Green Winter. Antibiosis was strongly indicated by Rio Verde. Head weights were quite variable and did not relate to larval density. Damage ratings, ranging from 2.6-3.7, also did not reflect the impact of different densities of larvae. Varietal preferences of P. rapae and T. ni were not similar although both insects avoided Red Acre for oviposition, and Rio Verde appeared to show antibiosis to both species.

HETEROSIS ESTIMATES FROM DIVERSE TOBACCOS TESTED IN TWO ENVIRONMENTS. D. L. Conner* and T. R. Terrill. Philip Morris, USA, Inc., Richmond, VA and VPI & SU Southern Piedmont Center, Blackstone, VA, respectively.

Evaluation of diverse Nicotiana stocks requires special testing procedures. Heterosis estimates were obtained for 12 tobacco cultivars and their hybrids, produced under two very different production and curing systems at the Southern Piedmont Center, Blackstone, Va. in 1980. Price ($/cwt) was so affected by the production and curing regimes that no differences in family heterosis were detected when the test was conducted as a flue-cured experiment, whereas, very large and highly significant differences were noted when dark-fired management was imposed. Yield and days from transplanting to flowering (one measure of maturation rate) are also discussed. The most critical concern is that environmental interactions mask true or full expression of hybrid family and hybrid potentials. None of the families or hybrids were consistently high or low for heterosis or mean performance, indicating that testing conditions must be considered very carefully to establish meaningful genetic estimates for characterizing diverse tobaccos and their hybrids.

AIR RECIRCULATION IN CROP DRYING. D.F. Cook*, D.H. Vaughan, and J.S. Cundiff*, Dept. of Agricultural Engineering, Va. Polytechnic Inst. and State Univ., Blacksburg, VA 24061.

Recirculation of air in peanut drying promises energy savings to the farmer. To determine the optimum recirculation strategy, 3 laboratory crop dryers (50cm x 50cm cross section) were designed and constructed. Tests were run with no recirculation (control), one-third recirculation, and two-thirds recirculation. Dry bulb and wet bulb temperatures were measured above and below the peanuts every 4 hours. Peanuts were sampled from the top of the column every 24 hours for moisture content determination. A deep bed peanut drying model was developed to simulate the drying process and was validated using the experimental data.

Recirculation can save 5-50% of the energy now used for peanut drying, depending on ambient conditions and initial moisture content. In a drying test of direct harvested peanuts (initial moisture content of 48% wet basis), the time to dry the peanuts to 10% w.b. was 70, 85.5, and 95 hours with no recirculation, one-third recirculation, and two-thirds recirculation, respectively. In a second test using peanuts which were dug, field dried, and then harvested (30% w.b. initial moisture content), drying times to reach 10% w.b. were 37.5 and 41.5 hrs. for no recirculation and two-thirds recirculation, resptly.

MAN'S RESPONSE TO ALIEN WEEDS: LEGAL ASPECTS, CURRENT STATUS AND OUTLOOK FOR THE FUTURE. W. E. Cooley, C. L. Foy and D. R. Forney. Dept. of Plant Pathol. and Physiol., Va. Polytech. Inst. and State Univ., Blacksburg, VA 24061.

Introduced weeds are a problem of man, created by man, and to be solved by man. Man's response to this problem has generally involved legal measures designed to prevent the introduction and spread of alien weeds. Included among these laws are the state and federal seed laws designed to deter the import and interstate movement of noxious weed seeds as a contaminant of crop seeds. Also included among these laws is The Federal Noxious Weed Act of 1974. This law contains various measures to prevent the importation of any plant or plant part, including seeds, of species included on the Noxious Foreign Weed List. The responsibility of implementing this act was given to the Animal and Plant Health Inspection Service (APHIS) of the U.S. Department of Agriculture. Included among these responsibilities are the implementation of quarantines, the conducting of port of entry inspections, and the recommendation of species for the Noxious Foreign Weed List. A brief history of the weed and seed laws will be discussed as well as the authority given to those responsible for their implementation. Also to be discussed is the role of APHIS concerning these laws and the degree to which these laws have been successful. Finally, the future outlook will be considered including proposals for future research.

WOOD FUEL FOR VIRGINIA AGRICULTURE-AN ECONOMIC ANALYSIS. J.S. Cundiff* and D.H. Vaughan, Dept. of Agricultural Engineering, Va. Polytechnic Inst. and State Univ., Blacksburg, VA 24061.

In Virginia tobacco curing requires 13 million gallons of LP gas equivalent, corn drying 7.5 million, peanut curing 1.4 million, and animal environment 5 million, for a total of 27 million. This total corresponds to the energy in 8.5% of the logging residue currently left behind in the states annual timber harvest. At 15% interest and a 5-year payback, a tobacco grower with five bulk curing barns can afford to invest $20,000 to convert to wood, assuming $1 per gallon for LP gas and $15 per green ton for wood delivered. Using the same assumptions, a peanut grower with a six-trailer drying system can afford to invest $7,400 to convert to wood. Neither of these analyses includes either investment tax credits or energy tax credits.

CROPPING SYSTEMS: EFFECT ON THE PEST COMPLEX IN VIRGINIA SOYBEANS. John Deighan. Dept. of Entomology, Virginia Tech, Blacksburg, Va. 24061

Four major soybean cropping systems are used in Virginia: conventional full-season, drilled full-season, double-cropped after barley, and double-cropped after wheat. The effect of the cropping system used on the soybean pest complex, including the corn earworm (Heliothis zea (Boddie)), the Mexican bean beetle (Epilachna varivestis Mulsant), the brown stink bug (Euschistus servus (Say)), the green stink bug (Acrosternum hilare (Say)), and the bean leaf beetle (Cerotoma trifurcata (Foerster)) was studied using the sweep net sampling technique. Conversion factors were calculated relating these counts to those that would have been obtained using the shake cloth sampling technique.

CONTROL OF BLACK CUTWORM, AGROTIS IPSILON (HUFNAGEL)(LEPIDOPTERA: NOCTUIDAE) IN FIELD CORN WITH VARIOUS INSECTICIDES. Joseph L. Despins* and James E. Roberts Sr., Dept. of Entomology, VPI&SU, Blacksburg, Va, 24061.

An evaluation was conducted for the insecticidal control of black cutworm larvae in field corn on the VPI&SU Agronomy Farm, Montgomery Co., Va. The plots were on land that had been in sod for several years. A tank-mix of Paraquat, Atrazine and Dual was applied prior to planting. The treatments consisted of a seed treatment, granular (7 in. band), broadcast, and postemergence. Each insecticide was replicated 4 times in a completely randomized design, plot size of 12 ft by 50 ft (38" rows). All granular insecticides were applied with a Gandy applicator on May 18. The postemergence foliar applications were sprayed on May 28 with a Solo backpack sprayer at 30 psi using 20 gallons of water/A.

Black cutworm larvae (3rd-5th instar) were placed in the treatment plots on May 29. Forty larvae were placed near the bases of 40 corn plants per treatment (2 center rows of each plot, 10 larvae/plot X 4 reps). The test was evaluated 6 days after the foliar treatments were applied. Insecticides evaluated were: Pounce 3.2EC, Dyfonate 20G, Lorsban 15G, Orthene 80SP, Ammo 2.5EC, and two rates of Lorsban 4E. Of these materials, Pounce 3.2EC and Dyfonate 20G gave the best control, based on posttreatment plant population counts.

EUROPEAN CORN BORER, OSTRINIA NUBILALIS (HUBNER) CONTROL IN FIELD CORN WITH STANDARD INSECTICIDES, J. L. Despins,* and J. E. Roberts, Sr., Dept. of Entomology, VPI&SU, Blacksburg, Va. 24061.

Several insecticides were evaluated for control of first generation European corn borer larvae in field corn, in separate tests in Montgomery County and Bedford County, Va. An application of Lannate L and Lorsban 4E was applied on early whorl stage corn as a rescue treatment at the Agronomy Farm, VPI&SU, and Counter 15G, Dyfonate 20G and Furadan 10G were applied as soil treatments for evaluation as systemic insecticides. Treatments were arranged in a completely randomized design, replicated 4 times in 12 ft by 50 ft plots (4 rows/plot, 38" spacing). Liquid insecticides were applied with a Solo backpack sprayer to the whorl of the plants on 19 July, and granular treatments were applied with a Gandy applicator at planting time. Evaluation of the tests consisted of splitting corn stalks from the tassel to the ground and recording the number of corn borer cavities.

Lannate L proved to be the most effective whorl treatment and Furadan 10G had the best control as a systemic insecticide.

MATING FREQUENCY IN CHICKENS: LONG-TERM SELECTION. E. A. Dunnington and P. B. Siegel. Virginia Tech, Blacksburg, VA 24061.

Cumulative number of completed matings (CNCM) in males was the selection criterion in a 23-generation bidirectional selection experiment. A sample of the foundation population was randomly bred each generation as a control. In generation 21, random samples were obtained from the selected lines and reproduced by relaxed selection for 2 generations. Mean CNCM changed from 7.14 ± 1.10 in generation zero to 21.61 ± 1.61 and 1.02 ± 0.28 in the high and low lines, respectively, in generation 23. The control adjusted regressions of CNCM in standard deviation units on generation were .06 ± .01 and -.03 ± .02 and the realized heritabilities were .18 ± .02 and .90 ± .13 for the high and low lines, respectively. The regressions of % nonmaters on generation were -.35 ± .09 and 2.80 ± .37 in the high and low lines, respectively. Body weights at 4 and 8 weeks of age decreased significantly in both selected lines during selection; within line phenotypic correlations between CNCM and body weights were negative and significant. Realized genetic correlations between CNCM and body weights were negative and large in the high line but positive in the low line. Relaxation of selection caused mean CNCM to move toward the control mean in the low but not the high line.

COMPARATIVE RETENTION QUALITIES OF FREEZE BRANDS AND SUBMANDIBULAR LATEX INJECTIONS FOR RAINBOW TROUT UNDER HATCHERY AND FIELD CONDITIONS. C. W. Fay* and G. B. Pardue.* Dept. of Fisheries & Wildlife Sciences, VPI & SU, Blacksburg, VA 24061.

Retention percentages of freeze brands and blue submandibular latex injections for rainbow trout were similar under hatchery conditions; red latex injections were inferior. Seven week evaluations yielded 98.0%, 98.7% and 89.6% total retention for brands, blue latex and red latex injections, respectively. Thirteen week evaluations yielded 96.1%, 91.6% and 75.4% retention for brands, blue latex and red latex injections, respectively. Retention percentages for freeze brands under field (stream) conditions were similar to those observed under hatchery conditions. Thirteen and twenty-two week freeze brand evaluations yielded 98.1% and 91.9% total retention, respectively. Blue and red latex injections, evaluated after 27 weeks of combined hatchery and stream residence, yielded 91.2% and 33.3% retention, respectively. Red latex injections faded and blended into submandibular tissue more rapidly than blue latex injections. Blue latex injections tended to turn black over time and consequently were visible in the tissue longer than red latex injections. Overall, blue latex injections and freeze brands were equally efficient marking strategies, but the process of branding was 4-5 times faster than latex injections, with little difference in cost of materials and equipment.

EFFECTS OF SELECTED INSECTICIDES ON SOYBEAN PEST AND PREDATOR SPECIES. H. J. Ferguson and Robert M. McPherson*. Dept. of Entomology, Va. Polytechnic Inst. & State Univ., Blacksburg, Va. 24061.

Nine insecticides were applied as foliar sprays to field plots in Richmond County, Virginia, to determine their effects on corn earworms (Heliothis zea (Boddie)), green cloverworms (Plathypena scabra (F.)), and arthropod predators (Nabis spp., Geocoris sp., and spiders). Corn earworm populations were significantly lower in all plots, except SIR 8514. Green cloverworms were significantly lower in all treated plots 2- and 5-days after treatment. Variability in predator counts between plots made statistical analyses difficult. Generally, the check, Sevin, and SIR 8514 plots had the highest number of predators, and the FCR 1272, Pounce , and Ammo plots had the lowest number of predators, 2-, 8-, and 14-days after application.

PHOSPHORUS POOLS IN LOBLOLLY PINE MEDIATED BY DIFFERENT ECTOMYCORRHIZAL FUNGI IN A PHOSPHORUS-FIXING SOIL. V. L. Ford*, J. A. Burger, Dept. of Forestry, and O. K. Miller, Jr. Dept. of biology, VPI & SU, Blacksburg, VA 24061.

Pot-grown loblolly pine seedlings were grown in a Cecil fine sandy loam (clayey, kaolinitic, thermic, Typic Hapludult) adjusted to five levels of available phosphorus (4, 8, 9, 25, and 41 ppm). Each seedlings was inoculated with one of four mycorrhizal fungi or left as a control. Average control-seedling foliar-P concentration (0.07%) was significantly lower than the average level of the colonized seedlings (0.10%). Seedlings colonized with Scleroderma aurantium Pers. had a significantly larger biomass (3.9 g) than seedlings colonized with Pisolithus tinctorius Pers. (2.1 g), Rhizopogon roseolus Tulasne (1.7 g), Thelephora terrestris (Ehrh.) Fr. (1.7 g), or control seedlings (1.1 g). Seedling biomass differences appear to be related to the symbionts' ability to take up phosphorus from this soil. Fungal polyphosphates in seedlings colonized with S. aurantium were significantly correlated with shoot length, needle length, and live crown length. This may indicate that polyphosphates in this fungus may be a controlling link in phosphate transfer to pine seedlings. Differences in biomass due to soil fertility were evident only at the lowest extractable phosphorus level.

WEED INTRODUCTIONS: A HISTORICAL PERSPECTIVE. D. R. Forney, C. L. Foy and W. E. Cooley. Dept. of Plant Pathol. and Physiol., Va. Polytech. Inst. and State Univ., Blacksburg, VA 24061.

Weeds are ubiquitous pests of farmland, roadsides, rights-of-way, lawns, gardens, and all other areas in which man desires to maintain a plant community of his choosing. They have special dispersal mechanisms and biological and physiological adaptations for invading disturbed habitats. Human activity has been the single most important factor affecting the spread of plants to new areas. Most of the serious weeds in North America are not native, but began to arrive here with European colonization. Many were brought intentionally as human or livestock feed, medicinal herbs, erosion control and landscape plantings, and ornamentals. Most weed introductions are inadvertent, however, and result from the transport of cargoes contaminated with weed seeds. Crop seed, hay, livestock bedding, packing materials and ships' ballast have been major sources. The most common weeds, those most widely occurring in association with man, have been nurtured, carried along, and distributed in a variety of ways throughout human history. This paper will review the biology of weeds, their origins, and the history of their transport to and colonization of North America.

A PRELIMINARY EVALUATION OF THE EFFECTS OF A COMMERCIAL CLEARCUT ON RUNOFF, WATER QUALITY AND SOIL SOLUTION CHEMISTRY OF FOUR SMALL WATERSHEDS IN THE VIRGINIA PIEDMONT. T. Fox*, and J. A. Burger. Dept. of Forestry, VPI & SU Blacksburg, VA 24061

Preliminary results from four watersheds equiped with H-flumes, gauge level recorders and coshocton wheel samplers indicate differences between the clearcut watersheds and the uncut control. Clearcutting stimulated hydrologic activity. In the year preceeding clearcutting, no runoff events were recorded in the clearcut watersheds. However, in the four months immediately following harvesting, suspended sediment loads were much greater in the disturbed watersheds. Conductivity values were also higher in runoff from the three clearcut watersheds (27.5, 28.9 and 115.0 m mhos) than in the uncut control (22.1 m mhos). Soil solution samples collected from porous cup lysimeters at 15 and 30 cm depths indicate increased mineralization rates in the clearcut watersheds. Orthophosphate levels averaged 0.20 ppm in the clearcut watersheds and 0.004 ppm in the uncut control. Ammonium (NH_4^+) and nitrate (NO_3^-) nitrogen levels were also greater in the clearcut watersheds (0.322 and 0.155 ppm, respectively) than in the undisturbed watershed (0.041 and 0.037 ppm, respectively). No significant differences were observed between the two sampling depths.

LABORATORY AND GREENHOUSE TECHNIQUES FOR STUDYING THE MOBILITY OF HERBICIDES IN SOILS. C. L. Foy, Dept. of Plant Pathol. and Physiol., Va. Polytech. Inst. and State Univ., Blacksburg, VA 24061.

Herbicides are now used extensively as "prescription tools" in technologically advanced agriculture. Public concern over pollution of the environment has also increased. Therefore, better manipulation and control of the distribution and fate of herbicides in the biosphere is desirable.

Herbicide mobility in the soil profile is important because of its possible influence on: weed control efficacy; herbicidal selectivity; herbicide dissipation; persistence of chemical residues potentially harmful to succeeding crops; and contamination of soil, water, air or food (feed) crops, perhaps beyond acceptable tolerance levels.

Three simple techniques were devised and employed to study the influence of soil type, properties of herbicides and adjuvants, amount and distribution of water, and other variables on mobility and persistence of herbicides in soils: (a) percolation through soil leaching columns - bioassay and/or radiochemical analysis of soil strata; (b) soil thin layer chromatography employing radiolabeled and nonlabeled herbicides and surfactants - visualization and/or quantitation of movement by UV detection, autoradiography, scanning or counting; (c) bioassay with repeated cropping (no drainage, persistence studies only).

INSULIN AND GLUCAGON RESPONSE TO XYLAZINE INJECTIONS IN LACTATING AND NONLACTATING COWS. F. B. Gaither*, J. H. Herbein*, and F. C. Gwazdauskas, Dept. of Dairy Science, VPI & SU, Blacksburg, Va. 24061.

To evaluate the possibility that glucagon is a causative factor in xylazine-induced hyperglycemia, 4 lactating and 4 nonpregnant, nonlactating Holstein cows were injected IV with 0, 5, 25 and 50% of the recommended dose (1.1 mg per 100kg BW). Doses were given weekly in a 4X4 latin square rotation within lactating (L) and nonlactating (NL) groups. Plasma glucose during the 3 hours following 0% (saline control) injection averaged 64 and 59 mg/100ml for L and NL, respectively. Plasma insulin and glucagon controls averaged .39 and .28 ng/ml for L and .86 and .46 ng/ml for NL, respectively. Following 25 and 50% doses, plasma glucose increases averaging 88% were associated with an average glucagon increase of 238% in L. Glucose increased 186% in NL with a glucagon increase of 74%. Responses to 5% doses were lower but similar to those noted above. A positive correlation between glucagon response and dose was apparent in both groups. Despite the larger glucagon response in L, hyperglycemia was not as severe as in NL, possibly due to glucose uptake by mammary gland (a process not dependent on insulin). Glucagon-stimulated gluconeogenesis with transient hypoinsulinemia may provide the physiological conditions for the hyperglycemic response to xylazine in cattle.

CORRELATIONS FOUND BETWEEN VARIOUS PEANUT DISEASE AND NUTRIENT CRITERIA. D. L. Hallock. Tidewater Res. and C.E.C., VPI&SU, Suffolk, VA 23437.

Research has been conducted recently at this Research Center in search of relationships among several plant nutrients and the peanut diseases pod breakdown (PB), Sclerotinia blight (SB) and Cylindrocladium black rot (CBR). Pod breakdown is caused principally by Pythium myriotylum or Rhizoctonia solani, SB by Sclerotinia minor and CBR by Cylindrocladium crotalariae.

Among the 11 nutrients investigated, PB was most closely related to Ca, K or Mg. Calcium depressed PB development whereas K, particularly, and Mg increased SB incidence when the disease was prevalent.

Foliar concentrations of K and Mn and soil K levels were positively related whereas soil Ca levels and Cu and Fe concentrations in peanut seed were negatively related to SB incidence. The concentrations of S. minor sclerotia in the soil were positively related to foliar K or seed K levels and negatively related to soil Ca or seed Fe levels.

The incidence of CBR in peanuts was positively related to foliar Ca or Fe levels and negatively to foliar Mn levels. Foliar P and Zn concentrations were negatively related to the number of C. crotalariae microsclerotia in the soil.

NONEQUILIBRIUM DEEP-BED LOW TEMPERATURE GRAIN DRYING. J.P. Harner*, J.L. Baker* and D.H. Vaughan, Dept. of Agricultural Engineering, Va. Polytechnic Inst. and State Univ., Blacksburg, VA 24061.

The use of low temperature drying methods has increased during the past decade due to the increased cost and dwindling supply of fossil fuels. Even though low temperature drying requires approximately half as much energy as conventional high temperature drying methods, the potential for spoilage and aflatoxin development prior to the completion of drying has slowed the adoption of low temperature drying in the southeastern United States.

Crop drying studies were conducted on a farm near Franklin, Va. using an experimental solar drying system. Corn was dried in a peanut curing system from 20 to 14% moisture content (wet basis) with a solar-supplemented combination drying system. This high airflow, thin layer, low temperature drying method reduced the time required to dry corn from 20 to 13% moisture content (w.b.) from three weeks to less than 12 hours. Airflow rates greater than 16 $m^3/min/m^3$ were maintained for grain depths less than 1 m and a temperature rise of 5.5°C. During this test period, 9.8 CJ of energy were provided by the solar system to dry 493 m^3 of corn. Total external energy demands were 0.10 kW/kg of water removed.

ALTERNATIVE ENERGY SOURCES FOR BULK TOBACCO CURING. J.P. Harner*, A.J. Lambert*, D.H. Vaughan, and J.L. Baker*. Dept. of Agricultural Engineering, Va. Polytechnic Inst. and State Univ., Blacksburg, VA 24061.

The 60,000 acres of flue-cured tobacco grown in Virginia require an equivalent of 13 million gallons of LP gas or 250 gallons/acre for curing. Increasing fuel cost is causing tobacco producers to seek methods for reducing energy use and to show interest in biomass and solar as alternate energy sources. Tobacco curing requires short term high energy demand which can be completely supplied by fuels such as coal or biomass, especially wood. Solar energy will only supplement fossil fuels since its economic potential is limited due to the large collector surface area and energy storage requirements to provide the high temperature needed for curing.

A solar energy system was designed and installed on Dogwood Farm near Axton, Virginia. The system which supplements energy requirements in two bulk barns should reduce fuel consumption by 30%. Water is heated in two 600 $ft.^2$ collectors, stored in a lagoon pond, and then pumped to either of the two barns upon demand. The enclosed lagoon is covered by a trickle type collector. The other pipe type collector is located in the attic of a machinery shed covered with a greenhouse fiberglass roof. Three automobile radiators serve as water-to-air heat exchangers in each of the curing barns.

A NOMOGRAPH FOR PREDICTING THE TRACTIVE PERFORMANCE OF A FOUR WHEEL DRIVE OFF THE ROAD VEHICLE, J.P. Harner*, J.V. Perumpral*, Dept. of Agricultural Engineering and W.B. Stuart*, Forestry Dept., Va. Polytechnic Institute and State University, Blacksburg, VA 24061.

As a result of mechanization of forest operations, wheel skidders are used extensively today. The production capacity of skidders depend on several factors such as terrain conditions, slope, vehicle weight, tire size, wheel slip, length of haul, number of logs hauled and experience of operator. The production capacity of a given skidder can be maximized if the load it can carry under a given field condition can be predicted. A model which can meet this need is the traction model developed by Wismer and Luth.

Wismer-Luth equation is straight forward for these who are mathematically oriented. However, most field operators and supervisors responsible for skidding operations may not have the background to use the model. In order to assist them, a nomograph based on the Wismer-Luth traction equation was developed. With the information on vehicle weight, tire size, slope, cone index and wheel slop available, one could employ the nomograph to predict the pull the vehicle can develop.

PARAMETRIC MODEL OF DRY MATTER DECOMPOSITION IN LOW TEMPERATURE DRYING. J.P. Harner*, D.H. Vaughan, J.L. Baker* and A.J. Lambert*. Dept. of Agricultural Engineering, Va. Polytechnic Inst. and State Univ., Blacksburg, VA 24061.

With the spiraling cost of fossil fuels in the last several years, energy conserving methods of drying grain benefit both the producer and consumer. An alternative to high temperature drying using LP gas is low temperature drying which uses solar energy. Low temperature drying has been successfully used in several midwestern states where average ambient temperature during the drying season is below 10°C. In the southeastern states corn is harvested earlier in the season when ambient temperatures are from 20° to 30°C, a more optimum growth range for microflora.

A parametric model for indicating dry matter decomposition in corn was developed for the southeast region of the United States where spoilage may occur before completion of drying. The model is based on the initial and final grain moisture contents, airflow rate, drying air temperature and relative humidity, and ambient air temperature. The parametric model gave an accuracy of 99% for an average drying season based on a history of weather data and 98% for the 1980 drying season based on actual weather data.

FUEL EFFICIENCY IMPROVEMENTS FOR PEANUT CURING WITH NATURAL AIR RECIRCULATION. J.P. Harner*, D.H. Vaughan, A.J. Lambert*, and J.L. Baker*, Dept. of Agricultural Engineering, Va. Polytechnic Inst. and State Univ., Blacksburg, VA 24061.

In 1981 Virginia farmers grew an estimated 42,000 ha of peanuts, requiring approximately 658 TJ of energy of which one fourth was for curing. Previous research indicates that the maximum airflow rate for peanut curing is 24 $m^3/min/m^3$ since higher rates do not increase the moisture removal rate enough to justify the additional energy costs. To prevent deterioration in peanut quality, the maximum curing temperature is limited to 35°C and up to 11°C difference between ambient and curing air temperature is permitted.

A six trailer drying facility was equipped with a bare plate solar collector and a means for partial recirculation of air. Exhaust air from above the peanuts in trailers along with ambient air was drawn into the collector inlet. Fans (850 m^3/min) moved this mixed air through the collector and to the trailers. The amount of recirculation depended on environmental conditions. Approximately 225 tonnes of peanuts were cured in 1980-81 from 21 to 10% moisture content (wet basis). The LP gas savings were 41.76 GJ for 68 t in 1980 and 51.88 GJ for 159 t in 1981. Due to a larger crop in 1981 a faster drying rate was used.

THE EFFECTS OF VIRGINIAMYCIN SUPPLEMENTATION AND SPACE ALLOWANCE ON SWINE PERFORMANCE. A. F. Harper*, E. T. Kornegay and K. L. Bryant, Dept. of Animal Science, VPI & SU, Blacksburg, Va. 24061

Five trials using 452 pigs were conducted to evaluate the addition of 0 or 11 mg/kg of virginiamycin (VIR) to the diets of pigs housed in pens with two space allowances. Space allowance (SA) was .24 or .12 m^2 per pig in starter trials and .78 or .43 m^2 per pig in grower-finisher trials. In the combined analysis of the three starter trials in which SA was altered by varying the number of pigs in a pen of constant size, VIR supplementation improved daily gain ($P<.05$) and feed efficiency ($P<.001$) while daily feed intake was not significantly effected. Reducing SA from .24 to .12 m^2 per pig depressed ($P<.01$) daily gain, daily feed intake and feed efficiency. In the combined analysis of two grower-finisher trials in which SA was altered by varying pen size with an equal number of pigs per pen, VIR supplementation had no significant effect on daily gain, daily feed intake or feed efficiency. Reducing SA from .78 to .42 m^2 per pig depressed ($P<.01$) daily gain and daily feed intake but had no significant effect on feed efficiency. No significant VIR x SA interaction was observed for starter or grower-finisher trials. Reducing the space allowance of weanling and growing-finishing pigs did not alter the response to virginiamycin.

POSTEMERGENCE CONTROL OF GRASS WEEDS IN SOYBEANS WITH NEW, SELECTIVE HERBICIDES. R. G. Hartzler and C. L. Foy. Dept. of Plant Pathol. and Physiol., Va. Polytech. Inst. and State Univ., Blacksburg, VA 24061.

Sethoxydim, CGA-82725, and RO 13-8895 are currently being developed for postemergence control of grasses in soybeans (Glycine max (L.) Merr.) and other broadleaf crops. The expanding acreage of solid-seeded soybeans and development of conservation tillage systems have increased the need for over-the-top grass herbicides. Adjuvants are frequently used with postemergence herbicides to enhance herbicide activity. Studies were conducted in which sethoxydim, CGA-82725, and RO 13-8895 were applied alone or in combination with Atplus 411-F, Savol oil concentrate, or X-77 spreader. The use of the adjuvants increased the activity of all three herbicides against large crabgrass (Digitaria sanguinalis (L.) Scop.). The effect of the adjuvants was greater with sethoxydim than with the other herbicides.

There were no significant differences among the adjuvants in enhancing crabgrass control by any of the three herbicides.

To determine the level of soybean tolerance to the compounds, eight cultivars grown commercially in Virginia were grown in a greenhouse. The soybeans were treated at the first trifoliate leaf stage with rates three to ten times greater than rates currently recommended. All cultivars showed excellent tolerance to these high rates of the herbicides.

GROWTH RESPONSE OF CORN (Zea mays L.) TO COMBINATION TREATMENTS WITH THE HERBICIDE EPTC AND OZONE OR ANTIOXIDANTS IN THE PRESENCE OR ABSENCE OF THE HERBICIDE ANTIDOTE R-25788. K.K. Hatzios. Dept. of Plant Pathology and Physiology, Va. Polytechnic Inst. and State Univ., Blacksburg, Va. 24061.

The effects of potential interactions of the herbicide EPTC (S-ethyl dipropylthiocarbamate) with the air pollutant ozone (O_3) or the antioxidants piperonyl butoxide (α-[2-(2-butoxyethoxy)ethoxy]-4,5-dimethylenedioxy-2-propyltoluene) and n-propyl gallate on the growth of corn seedlings were examined in the presence or absence of the herbicide antidote R-25788 (N,N-diallyl-2,2-dichloroacetamide) under greenhouse conditions. EPTC formulated either alone or in combination with the antidote R-25788 (ERADICANE®) was applied preplant incorporated at 4.5, 5.6, and 6.7 kg/ha and it was evaluated against fumigation with 0.2 and 0.3 ppm of ozone or against 4.5, 6.7, and 8.9 kg/ha of the two antioxidants both applied preplant incorporated. Growth response of corn, measured as shoot dry weight, revealed that the higher rates of EPTC in the presence of the antidote R-25788 interacted synergistically with 0.3 ppm of ozone or with the high rates of the two antioxidants. Since ozone or antioxidants are known to interfere with mixed function oxidase systems in plants and animals, these results appear to be supportive of the hypothesis that R-25788 may act by stimulating the oxidation system that sulfoxidizes the herbicide EPTC in corn.

HERBICIDE ANTIDOTES: PAST, PRESENT, FUTURE. K.K. Hatzios. Dept. of Plant Pathology and Physiology, Va. Polytechnic Inst. and State Univ., Blacksburg, Va. 24061

The concept of using herbicide antidotes offers a potential alternative for increasing the selectivity of currently available herbicides. A desirable herbicide antidote is a chemical that selectively protects crops from herbicide injury without protecting weeds. This selectivity is the result of either a very specific crop/herbicide/antidote interaction or a selective treatment such as the dressing of crop seeds with the antidote. Chemicals currently used as herbicide antidotes include: NA (1,8-naphthalic anhydride), R-25788 (N,N-diallyl-2,2-dichloroacetamide), CGA-43089 (α-[(cyanomethoxy)imino]benzeneacetonitrile), CGA-92194 [N-(1,3-dioxolan-2-yl-methoxy)imino-benzeneacetonitrile], and MON-4606 (2-chloro-4-trifluoromethyl-5-thiazolecarboxylic acid, benzyl ester). All these chemicals can antidote to some extent the effects of chloroacetanilide and carbamate herbicides on grass crops such as corn and grain sorghum. Rather than merely preventing the entry of herbicides into the plant, herbicide antidotes work inside the plant to counteract the action of herbicides by either competing with them for a common site of action or by stimulating their metabolic detoxication in the protected crops. Development of effective antidotes that could protect broadleaved crops against injury from herbicidal photosynthetic inhibitors presents the greatest challenge to pesticide industry in the near future.

THE ATTRACTION OF THE PINE INSECTS BY OXYGENATING MONOTERPENES. Copyrighted. H.J. Heikkenen, Dept. of Entomology, VPI & SU, Blacksburg, VA 24061

Forest tests were conducted by passing oxygen, nitrogen and compressed air through alpha and beta pinene, and myrcene during October 1981 in Nottoway County, VA and November 1981 in Baker and Levy Counties, FL.

In Virginia, Xylotrechus was the most abundant genus; in Florida, Xyloborus. Other families attracted were: Scolytidae, Cerambycidae, Curculionidae, Siricidae, Platypodidae and Tenebrionidae. Also Ichneumonidae, Cleridae, Cucujidae, Staphylinidae, Histeridae and Chrysopidae.

An application has been made to patent the process of oxygenating a given plant's volatile compounds for the purpose of attracting the plant's insect pests. (Supported by Weyerhaeuser Company)

METHODS USED TO MEASURE THE IMPACT OF INSECTICIDES ON NON-TARGET TERRESTRIAL ARTHROPODS. D. J. Hilburn. Dept. of Entomology, Va. Polytechnic Inst., Blacksburg, Va. 24061

Laboratory studies have indicated that many insecticides are toxic to a broad spectrum of insects and other arthropods. Some of the methods which have been used to quantify the impact of commercial applications of these insecticides on non-target terrestrial arthropods include: Malaise traps, pitfall traps, light traps, deadfall traps, fumigation under tents, branch sampling, caged specimens, stream drainage "traps", bush beating, and sand tracking. The advantages and disadvantages of each are discussed.

NET ASSIMILATION RATES IN SEEDLINGS OF PINUS X RIGITAEDA UNDER TWO MOISTURE REGIMES. Gary R. Hodge* and Peter P. Feret. Forestry Department, VPI & SU, Blacksburg, Virginia 24061.
Seedling growth characteristics in six families of Pinus X rigitaeda were examined using growth analysis techniques including relative growth rate, net assimilation rate, and leaf area ratio. Seedlings were planted in leach tubes in a modified split plot design, and were placed under two watering regimes, control and stressed. Mean plant moisture stress at the end of drying cycles was 1.32 bars for the control and 4.19 for the stressed, and was significantly different at α=0.001. Growth characteristics were analyzed separately by treatment. In the control, ANOVA showed family differences in only one of eight variables. The stress treatment elicited more family variation, as significant differences were found in seven variables. Correlations were made between family means for growth analysis variables and adult tree height and volume. Many significant relationships were found with height, but none with volume. The potential of growth analysis on seedlings as an early screening technique in P. X rigitaeda improvement programs may be limited by the lack of relationships with volume.

MICRONUTRIENT FERTILIZATION OF FLUE-CURED TOBACCO: I. BORON. J. L. Jones* and R. G. Leslie*. VPI & SU Southern Piedmont Center, Blackstone, Va. 23824.
Thirteen field experiments were conducted in 1980 and 1981 to study the effects of B on the yield and quality of flue-cured tobacco. The soils and environments were representative of those where the crop is grown in Virginia. Treatments were band applied in 1980 and broadcast in 1981 at rates of 0, 0.56, 1.12, and 1.68 kg/ha B. Boron concentration in the soil and leaf tissue increased with B applications with the levels being highest where the treatments were band applied in 1980. Severe toxic effects were observed at 3 of the 5 locations where B was band applied at 0.56 kg/ha. In these field studies, no significant increase in yield or value per hectare was obtained from B applications. Yields tended to be lower with B treatments where toxicity was observed.

SEASONAL MOVEMENTS OF BROWN TROUT (Salmo trutta) IN A VIRGINIA STREAM. Daniel Josephson* and Garland Pardue.* Dept. of Fisheries & Wildlife Sciences, VPI & SU, Blacksburg, VA 24061.

Brown trout (Salmo trutta) movements were monitored from June through October 1981 in a 2400 meter section of the Conway River, Virginia. The brown trout population displayed a net upstream movement of 42.2 meters. Age I+ fish displayed a net upstream movement of 48.7 meters. Age II+, III+ and IV+ did not move from original marking sites. Pennant tag retention was 78.9%. Tagging effects were minimal based on comparisons of length and condition factor between tagged versus untagged age I+ fish. No significant differences existed between the two groups.

EFFECTS OF SEED-COATING ALFALFA WITH EPTC-IMPREGNATED LIME ON STAND, VIGOR AND FIRST YEAR PRODUCTION. J. S. Krecker and C. L. Foy. Dept. of Plant Pathol. and Physiol., and D. D. Wolf, Dept. of Agron., Va. Polytech. Inst. and State Univ., Blacksburg, VA 24061.

'Vancor' alfalfa field plots were established to study the effects of seed-coating with EPTC-impregnated lime on stand, vigor and first year production; also to compare conventional (broadcast and drilled) with sod plantings. Interactions between insecticides (carbofuran and fonofos) with EPTC-impregnated lime-coated seed were also investigated.

The most vigorous, productive stands were established by broadcast seeding. EPTC-impregnated, lime-coated seed (2 lb EPTC/A), drill-seeded at 22 lb/A after incorporation of granular carbofuran or fonofos (1.4 lb/A), produced significantly weaker stands than did untreated seed, drill-planted after incorporation of EPTC 7E (3.5 lb/A) + insecticide; yield data at 1/10 bloom confirmed these observations. When broadcast seeded at 22 lb/A, EPTC-treated seed (2 lb EPTC/A) without insecticide treatment produced excellent yields, comparing favorably with conventional EPTC 7EC + insecticide treatments. When sod-planted, the EPTC-treated seed + granular insecticide treatments produced significantly less biomass per plot than did the untreated seed + granular carbofuran treatment. Further work is needed to demonstrate practical field effectiveness of the approach.

EFFECTS OF RIPPING AND DISKING ON LOBLOLLY PINE (PINUS TAEDA L.) SURVIVAL AND GROWTH ON THE GEORGIA PIEDMONT. D. O. Lantagne*, and J. A. Burger. Dept. of Forestry VPI & SU, Blacksburg, VA 24061

Loblolly pine establishment and growth are affected by the site preparation of Cecil soils (clayey, kaolinitic, thermic, Typic Hapludult) on the Georgia Piedmont. Treatments, consisting of ripping and disking, were applied in factorial combination on four sheared and raked sites. One year after planting, results showed significant increases in survival and growth of trees on the disked and ripped treatments. Disking improved survival by 9% and stemwood volume by 17%, while ripping improved survival and volume by 20% and 17%, respectively. The ripping and disking combination improved survival by 12% over disking alone, while survival on the ripping treatment, and stemwood volumes on either treatment alone, were not increased.

MICRONUTRIENT FERTILIZATION OF FLUE-CURED TOBACCO: I. BORON. J. L. Jones* and R. G. Leslie*. VPI & SU Southern Piedmont Center, Blackstone, Va. 23824.

Thirteen field experiments were conducted in 1980 and 1981 to study the effects of B on the yield and quality of flue-cured tobacco. The soils and environments were representative of those where the crop is grown in Virginia. Treatments were band applied in 1980 and broadcast in 1981 at rates of 0, 0.56, 1.12, and 1.68 kg/ha B. Boron concentration in the soil and leaf tissue increased with B applications with the levels being highest where the treatments were band applied in 1980. Severe toxic effects were observed at 3 of the 5 locations where B was band applied at 0.56 kg/ha. In these field studies, no significant increase in yield or value per hectare was obtained from B applications. Yields tended to be lower with B treatments where toxicity was observed.

METACARPAL AND METATARSAL CHARACTERISTICS IN GROWING BOARS AS INFLUENCED BY RESTRICTED ENERGY INTAKE AND ELEVATED VITAMINS AND MINERALS. A. J. Lepine*, E. T. Kornegay, J. L. Baker*, H. P. Veit, J. W. Knight, D. R. Notter and H. S. Bartlett*, Dept. of Animal Science, VPI & SU, Blacksburg, Va. 24061

Eighty 35-day-old crossbred boars were used in a 2 x 2 factorial design to evaluate the effects of ad libitum (AL) vs 75% of ad libitum (RT) intake and 100 vs 150% (150-MV) of NRC daily minerals and vitamins on dimensional and mechanical properties of metacarpals (MC) and metatarsals (MT). Boars were necropsied at 15 d intervals from 120 to 330 d of age with removal of the 3rd and 4th MC and MT for determination of various dimensional and mechanical properties. Examined at the same age, AL-fed compared with RT-fed boars exhibited heavier ($P<.05$) bones after 190 d on test and longer bones after 295 d. AL-fed boars had larger ($P<.01$ to .1) MC and MT shaft diameters by 295 d while mineral-vitamin level had little effect. Trends for longer and heavier MC were evident on the 150-MV diet. Energy level had little influence on bone wall thickness while boars fed the 150-MV diet had MC and MT with thicker ($P<.1$) walls by 190 d. Feeding the 150-MV diet increased breaking strength, stiffness, flexural modulus and Young's modulus of elasticity with more consistant effects on MT than MC; energy level had little effect. Body weight correction removed or reversed the effects of energy but had little influence on mineral-vitamin effects.

EFFICACY OF SALINOMYCIN FOR IMPROVED PERFORMANCE IN GROWING-FINISHING SWINE. M. D. Lindemann, VPI & SU, Tidewater Research Center, Suffolk, Va. 23437 and E. T. Kornegay, Dept. of Animal Science, VPI & SU, Blacksburg, Va. 24061

Seventy-six purebred and crossbred pigs were used in a dose response trial to evaluate the effect of the anbitiotic, salinomycin, on average daily feed (ADF), average daily gain (ADG) and feed/gain (F/G). The antibiotic was added to standard corn-soybean meal diets at the levels of 0, 50, 75 and 100 g/ton. During the growing period (10 to 36 kg), the addition of salinomycin to the diet improved both ADG ($P<.025$) and F/G ($P<.025$). All three dose levels exceeded the control, but the response for ADG and F/G was greatest on the 75 g/ton level with ADG and F/G both improved 9%. During the finishing period (36 to 98 kg) F/G was improved ($P<.05$) only on the 75 g/ton level; no significant improvement in ADG was exhibited. For the total trial period, the 75 g/ton level of salinomycin produced the greatest response - improving ADG 6.1% and F/G 7.2%. There was no effect ($P>.05$) on ADF during this trial.

THE OPERATION OF A DIESEL ENGINE USING 100% SOYBEAN OIL FUEL. M. H. Lovingood*, E. S. Smith*, and G. H. Hetzel*. Dept. of Agricultural Engineering, Va. Polytechnic Inst. and State Univ., Blacksburg, Va. 24061.

Recent shortages and increasing prices of petroleum fuels have intensified efforts to find alternate fuels for engines. Vegetable oils seem to hold some promise as a substitute for diesel fuel. To investigate this potential, a direct-injected, naturally aspirated diesel tractor engine was operated at five levels of power burning 100% crude, degummed soybean oil. Initially the engine started and ran normally with power and fuel consumption comparing favorably to that with diesel fuel. However, the test was terminated at 60 hours after the engine achieved only 85% of its initial power, because of sticking piston rings. Other less serious problems were encountered with fuel filtration and a carbon-like buildup on fuel injectors. However, no measureable engine wear occurred during the test and the fuel injection system pumping rate remained constant throughout. Based on these results, soybean oil cannot be recommended for long-term use in a compression ignition engine.

THE PRODUCTION ECOLOGY OF BROOK TROUT (Salvelinus fontinalis) IN SOUTHWEST VIRGINIA. G. L. Lucchetti* and G. B. Pardue.* Dept. of Fisheries & Wildlife Sciences, VPI & SU, Blacksburg, VA 24061.

Brook trout (Salvelinus fontinalis) populations in four second order streams varying in water hardness (4-8/mg/ℓ), with two 200 m sections per stream, were sampled quarterly betweem May and December 1981. Production (P) was highest (4.15 g/m^2 yr) in a hardwater (81 mg/ℓ) section of Ewings Run, Craig Co.; however, no trend between hardness and P was apparent. P was lowest (0.31 g/m^2 yr) in a section of Lick Run, Bath Co., predominated (59%) by bedrock substrate. P was as variable within streams (SD ±.15 = ±1.41) as among streams (SD ± 1.13). Age 0 fish contribted from 40.3% - 66.2% to P in three of the study streams, followed by Age I (16.4% - 55.4%), Age II (6.0% - 31.8%), and Age III (-2% - 11.6%) fish. In one stream Age 0 fish contributed only 10.5 - 22.3% to P, while Age I and Age II fish contributed from 50.2% - 68.8% and from 20.7 - 27.6%, respectively. Maximum P was in the May-July period with 47.8% - 107.0% of total P occurring in that time. Minimum P was in the July-October period (-27.8% - 25.3%).

EFFECTS OF SOIL MOISTURE AND SOIL TEXTURE ON THE SOUTHERN CORN ROOTWORM. Patrick F. Lummus* and J.C. Smith, Tidewater Research Center, Suffolk, Va. 23437.

Effects of soil moisture and soil texture on the southern corn rootworm were studied in a series of experiments conducted in 1980-81. Both environmental parameters were found to significantly effect SCRW survival. Of the two, soil moisture was ascertained to be of primary importance. These results contradict those of past researchers. This conflict is deemed to be a result of differences in instrumentation used in establishing soil moisture differentials. Prior researchers relied on soil tensiometers, which have been found by soil physisists to be highly inaccurate in monitoring soil moisture conditions which are not very close to field capacity. The authors employed a gravimetric technique in which a differential was established by monitoring the weight of the soil, maintaining treatments with daily selective waterings.

LOCUST LEAF MINER DEVELOPMENT ON SOYBEAN. R. M. McPherson. Dept. of Entomology. Va. Polytechnic Inst. and State Univ., Blacksburg, VA 24061.

Larvae of the locust leaf miner, Odontota dorsalis (Thunberg), were observed completing development on soybean in 3 Va. counties in 1981. Larval infestations were present in early-planted (full-season) fields of 'Essex' and 'Bay' varieties. These same varieties planted later in the season (double-cropped after wheat or barley) were not attacked by this pest. Feeding damage was confined to the upper 1/3 of the plant foliage, with up to 10% of these upper leaves containing one or more mines. Mines average 21.86 mm $\pm$ 4.85 long and 13.43 mm $\pm$ 2.31 wide.

SWEEP NET AND GROUND CLOTH SAMPLING FOR INSECTS IN SOYBEAN. R. M. McPherson, Dept. of Entomology, Va. Polytechnic Inst. and State Univ., Blacksburg, VA 24061, and W. G. Rudd, Dept. of Computer Sci., La. State Univ., Baton Rouge, LA 70803.

Population densities of Arthropod species were measured with a 38-cm diameter sweep net, a 3 ft. ground cloth, and direct observation in 3 different soybean cropping systems in eastern Virginia. Ten 25-sweep samples were randomly taken in each field to derive a mean population density within the fields for all Arthropod species encountered. Ground cloth samples and direct observations were taken adjacent to the sweep net sites in each field. Regression analyses for Mexican bean beetle revealed high correlations between the three techniques in conventional and drill planted regimes. High correlations were detected for corn earworm larvae in double-cropped soybean.

Other, more mobile species showed lower correlation coefficients, particularly the small predatory species. Tables to convert from sweep net samples to populations that would have been measured during the 'direct' method are provided.

REARING METHODS FOR REDUVIOLUS AMERICOFERUS (CARAYON) (HEMIPTERA: NABIDAE). P. R. Mehring* and R. L. Pienkowski. Dept. of Entomology, Virginia Tech, Blacksburg, VA 24061

Our goal was to rear groups of nabids of known age in the laboratory. Adult nabids were collected from the field with sweep nets and placed in groups of 12 on 0.3 m alfalfa stems in 6 cm diam. plastic tubes. We maintained these adult colonies at 14L:10D photoperiod, feeding them lab-reared vestigial-winged Drosophila melanogaster. About 10 days after the first eggs were laid we transferred the adults to new tubes. Each day the first instar nabids were transferred to cages made from 20-dram (6 cm x 4 cm diam.) plastic vials. We fed the 8 or more early instars per cage 8 frozen Drosophila every other day. When the nymphs entered the third instar, we transferred them to individual 10-dram shell vials which contained 5 ml medium and all life stages of Drosophila. This provided food for the nymphs until adulthood. The method provided several hundred early instar nabids each day. With modifications it could be used to rear Geocoris and other insect predators.

TOPOGRAPHIC PARAMETERS AS ESTIMATORS OF FOREST SITE QUALITY IN THE APPALACHIAN OAK FOREST REGION OF VIRGINIA. Tina M. Meiners*, David Wm. Smith, and Terry L. Sharik. Forestry Dept., VPI & SU, Blacksburg, Va. 24061.

A forest site quality index based on topographic parameters of aspect, slope inclination and slope position was used to investigate soil moisture and plant moisture stress relationships on the southeast face of Potts mountain in Craig County, Virginia. Topographical effects on available water are especially pronounced during critical late season rainfall levels encountered in the Ridge and Valley Physiographic Province of Virginia. Thus, where plant available soil moisture is the most limiting environmental factor affecting growth, topographic factors that reflect moisture supply may serve as useful indices in predicting relative site quality.

A gradient of index values representing the most xeric to most mesic was established to sample the range of existing moisture conditions on the site. Results support the relationship between topographic variable classification and moisture gradients existing on the study site. Although plant moisture stress is more variable than soil moisture content, the relationship between soil moisture gradients and plant moisture stress was significant.

HPLC ANALYSIS OF CHLOROTHALONIL AND CARBARYL. V. E. Melchor, C.C. Lewis, L.P. Lue* Pesticide Research, Virginia State University, Petersburg, VA 23803

Chlorothalonil, fungicide, and carbaryl, insecticide, are sometimes used together on vegetable crops to combat diseases and insects which are simultaneously present. With this method the analyst is able to detect both compounds and their major metabolites with one injection. Detection of chlorothalonil (tetrachloroisophthalonitrile), DAC-3701 (4-hydroxy-2, 5, 6 trichloroisophthalonitrile), carbaryl (1-Naphthyl-n-methyl carbamate) and 1-naphthol was accomplished by HPLC detection. The conditions of analysis were as follow: Waters HPLC-440 Fised detector (254 nm), solvent system, 60% methanol and 40% water (.5% acetic acid), flow rate 4.0 ml/min., sensitivity, 1.0, column-C_{18} 10 μ RCM(R).

Prior to analysis, clean-up time for samples was shortened with use of C_{18} Sep-Pak(R) employing varying amounts of methanol in aqueous solutions. At methanol aqueous solutions rates of 50%, 60%, 60% and 70%, recovery percentages of the four compounds using this mode of clean-up were 85.82% DAC-3701, 116% chlorothalonil, 72.54% carbaryl and 88% 1-Napthol respectively.

With this method the detection of DAC-3701, a major metabolite of chlorothalonil is easily performed without derivatizing to the n-propyl ether which is the mode of analysis now described in the literature. Conclusively, this method in totality improves on the methodology by being efficient and saving the amount of solvents used.

BROAD-SENSE HERITABILITY ESTIMATES AND REGRESSION MODELS FOR CONE AND SEED CHARACTERISTICS OF SEED ORCHARD LOBLOLLY PINE. S. A. Merkle*, P. P. Feret. Dept. of Forestry, VPI & SU, Blacksburg, VA 24061 and D. L. Bramlett*, USDA Forest Service, Southeastern Forest Experiment Station, Macon, Georgia 31208.

Five ramets from each of fifteen loblolly pine clones were randomly chosen from a seed orchard population to study within-clone and among-clone variation in cone and seed characteristics. Five healthy cones were randomly sampled from each ramet for Cone analysis. Analysis of variance showed that seed potential, seed efficiency, extraction efficiency and germination efficiency were significantly affected by clone, age-class and ramet. Broad-sense heritability estimates computed for these characters revealed a relatively high degree of genetic control, the highest estimate being for germination efficiency with r = .67. In an effort to reduce the time and effort needed to complete the full cone analysis procedure, regression models were developed to relate seed potential and seed efficiency of cones to clonal averages for these values obtained the preceding year and easily-measured cone characters such as length, width and number of extracted seed. The best models obtained for seed potential and seed efficiency accounted for 60 percent and 70 percent of the variation respectively.

WITHIN-CROWN VARIATION IN CONE AND SEED CHARACTERISTICS OF SEED ORCHARD LOBLOLLY PINE. S. A. Merkle*, P. P. Feret. Dept. of Forestry, VPI & SU, Blacksburg, VA 24061 and D. L. Bramlett*, USDA Forest Service, Southeastern Forest Experiment Station, Macon, Georgia 31208.

Five 8-year-old grafted loblolly pine individuals with cones well-distributed throughout their crowns were chosen from a seed orchard population for study of within-crown variation in cone and seed characteristics. Tree crowns were divided into 3 equal-length height zones (top, middle and bottom) and 4 quadrants (North, South, East and West) to create a total of 12 sampling regions. Three healthy cones were collected for cone analysis from each crown region of each sample tree for a total of 36 cones per tree. While height zone had no significant effect on any of the variables of interest, quadrant was found to have a significant effect on number of empty seed per cone and consequently on seed efficiency. Cones from the south quadrant had significantly fewer empty seed and significantly higher seed efficiencies than cones from the other three quadrants, possibly due to prevailing southerly winds during the time of pollination. Extraction efficiency declined with increasing branch diameter at the point of cone attachment and increased with increasing branch order.

TESTING OF LEG PROTECTIVE DEVICE FOR CHAINSAW OPERATORS, G.S. Monroe*, J.V. Perumpral*, Dept. of Agricultural Engineering and W.B. Stuart*, Forestry Dept., Va. Polytechnic Inst. and State Univ., Blacksburg, VA 24061.

Leg Protective Devices, LPD's are protective pads which are used as a form of protection against injury resulting from contact with the moving chain of a chainsaw. LPD's are commonly made of multiple layers of nylon ballistic materials. In the U.S. the use of LPD's is not mandatory due to the lack of a standard for their performance. In order to help establish a standard, a test facility and procedure for testing LPD's were developed and is described in this paper. The test facility consists of a simulated leg and a chainsaw operating under controlled conditions. The instrumentation developed for recording the time required to cut through the LPD and the average chain speed during cutting is also discussed. Eight different LPD's were tested. Based on the results of this study, a volutary standard for the LPD's was developed by the American Pulpwood Association.

EFFECTS OF ROWSPACING AND PLANTING DATE OF SOYBEANS ON INSECT POPULATION LEVELS. D. A. MORRIS* and J. C. Smith. Dept. of Entomology, VPI & SU, Blacksburg, Va. 24061

A planting date x rowspacing study using four commercial varieties was conducted at Tidewater Research and Continuing Education Center in 1981. Each variety was planted at a population of 150,000 plants per acre in ten inch and thirty inch row spacings on June thirteenth and again on July thirteenth. Weekly sweep net samples showed no significant differences in number of early season insects, spotted cucumber beetle, Diabrotica undecimpunctata howardi (B.) and bean leaf beetle, Ceratoma trifurcata (F.), between planting dates or row spacings. Of the late season insects, only the corn earworm, Heliothis zea (B.), showed a significant difference. Populations were higher in the late planting. Nabis spp. populations were higher in the late planting but no other predator exhibited a planting date or row spacing response.

REACTION OF PEANUT GENOTYPES TO SCLEROTINIA MINOR. R. Walton Mozingo, D. M. Porter* and P. M. Phipps*. Tidewater Research and Continuing Education Center, Suffolk, Virginia 23437.

Twelve peanut (Arachis hypogaea) genotypes were rated for reaction to Sclerotinia minor on heavily infested soil at the Tidewater Research and Continuing Education Center in Suffolk, Virginia in 1979 and 1981. In 1979 nine genotypes were less susceptible to S. minor than 'Florigiant' a cultivar currently grown on over ninety-five percent of the peanut acreage in Virginia. Of the same twelve genotypes, six were less susceptible to S. minor than 'Florigiant' in 1981. One genotype which showed the most resistance to S. minor in these ratings was recently released as 'Virginia 81 Bunch'. In 1979, based on a rating of 0 to 10 (0 = no disease and 10 = all plants dead) 'Virginia 81 Bunch' had a rating of 3.2 compared to 5.6 for 'Florigiant'. In 1981, 'Virginia 81 Bunch' had a rating of 1.49 compared to 2.20 for 'Florigiant' based on a rating system of 1 to 5 (1 = no disease and 5 = all plants dead). In both years, ratings were statistically different between cultivars.

FACTORS AFFECTING RETAIL, WHOLESALE, AND EX-VESSEL OYSTER PRICES. Karen Mundy* and Oral Capps, Jr.* Dept. of Agricultural Economics, Va. Polytechnic Inst. and State University, Blacksburg, VA 24061

A recursive model of the price formation process in the marketing system for oysters in the Chesapeake Bay was developed. The model explained over 90 percent of the annual variation in the retail price, wholesale price, and the ex-vessel price of oysters. Disposable income and the consumer price index for fish significantly influenced the retail price of oysters; the retail price, landings in the Chesapeake Bay, and marketing costs significantly influenced the wholesale price of oysters; the wholesale price significantly influenced the ex-vessel price of oysters. The impact of oyster consumption on the retail price, the impact of landings from outside the Chesapeake Bay on the wholesale price, and the impact of landings in the Chesapeake Bay on the ex-vessel price were not statistically different from zero.

GROWTH PATTERNS OF F_1 STRAIGHTBRED AND CROSSBRED COWS AT BLAND CORRECTIONAL FARM. N. Nadarajah*, T. J. Marlowe and D. R. Notter, Virginia Polytechnic Institute and State University, Blacksburg, Va. 24061

Growth patterns were studied on 5 cow breed types (born 1970-75) from birth to maturity. These were 39 Angus (AA), 102 Hereford (HH, Hx) straightbred (SB) and 49 Simmental x Hereford (SH), 51 Charolais x Hereford (CH) and 33 Simmental percentages (Sm%) crossbred (XB) types. Half of the Herefords (Hx) produced XB calves. All cows were treated alike. Weights were recorded at birth (br), weaning (wn), 12 mo, 18 mo and at 12 mo intervals thereafter to maturity. Significant ($P < .0001$) breed type differences were observed at all stages of growth. AA calves were smaller at birth (28 kg *vs* 36.5 kg) and grew faster to wn (0.64 *vs* 72 kg ADG) than HH calves. Crossbred cows weighed more at all periods and were heavier at maturity. Among XB types, Sm% grew fastest, followed by CH and SH cows but CH were heaviest at maturity (588 kg). XB advantage in wn wt over HH was 36 kg for Sm%, 21 kg for CH and 19 kg for SH. Avg mature wts of XB cow types were 94, 83, and 74 kg more than HH for CH, Sm% and SH, respectively. Year effects were significant on all wts, but br x yr effects were significant only at wn, 12 and 30 mo. Weights were influenced by both dam age and animal age in early growth.

SWEET SORGHUM STORAGE FOR PROCESSING INTO ALCOHOL. William Perdue* and J.S. Cundiff, Dept. of Agricultural Engineering, Va. Polytechnic Institute and State Univ., Blacksburg, VA 24061.

Sweet sorghum was hand cut, topped at 2m, and aligned whole stalks packed into two column dryers at 260 and 450 kg/m^3 loading density. It was dried 7 days at 27C, and the moisture content (w.b.) reduced 6 and 4% respectively. In a second experiment sorghum was loaded at 250 and 350 kg/m^3, dried at 35C for 6 days, and the moisture content reduced 4% in both columns. Total non-structural carbohydrates (TNC) was 30.6 and 39% for the dried and undried sorghum in experiment 1. These percentages did not change over 3 months of open-shed storage. In the second experiment, the TNC changed from 46.7 to 31.8% in the undried sorghum, and from 35 to 37.4% in the dried sorghum during 3 months of storage. Drying was beneficial in the preservation of fermentables in the second experiment. Development of these storage procedures will substantially improve the potential of sweet sorghum as an ethanol feedstock.

TEMPERATURE EFFECTS ON DEVELOPMENT AND REPRODUCTION OF THE SOUTHERN RED MITE OLIGONYCHUS ILICIS (McGregor). S. L. Poe and G. H. Childs. Dept. of Entomology, VPI and SU, Blacksburg, VA 24061.

Southern red mites completed development of all stages under constant temperatures ranging from 15.5 to 35^{o}C. Developmental times of all stages and adult longevity decreased as temperature increased. Males developed more rapidly than females at all temperatures except at 26.5^{o}C. The developmental curves for all stages were cubic. Mortality curves for males and females dropped more abruptly as temperature increased. The survival rate of O. ilicis was greatest for eggs, and the highest mortality occurred in the larval stage. The net reproductive rate was highest (7.0961) at 26.5^{o}C. The mean generation time was shortest (2.5695) at 35^{o} and longest (7.3119) at 21^{o}C. The intrinsic rate of natural increase was greatest (0.4694) at 26.5^{o}C. The number of degree days required for the development of the egg was greater than for any other mature stage at 6 different temperatures.

EFFECTS OF VIRGINIAMYCIN SUPPLEMENTATION ON THE NUTRIENT DIGESTIBILITIES IN SWINE FED TWO LEVELS OF CRUDE FIBER. V. Ravindran, E. T. Kornegay, K. L. Bryant and K. E. Webb, Jr. Dept. of Animal Science, VPI & SU, Blacksburg, Va. 24061

Three metabolism trials, each involving 12 crossbred gilts averaging 35.2 kg body weight, were conducted to determine the effects of two levels (3.2 and 7.3%) of crude fiber and two levels (0 and 11 ppm) of virginiamycin on nutrient digestibilities in growing swine. Treatments were arranged in a 2 x 2 factorial design. All diets were isonitrogenous (16% crude protein) and isocaloric (3280 kcal ME/kg). Digestibility of dry matter (DM), energy (E), cell wall (CW), cell content, acid detergent fiber (ADF), hemicellulose, cellulose, lignin and ash were depressed ($P<.001$) in gilts fed the high fiber diet. Virginiamycin supplementation had no effect on the nutrient digestibility of the low fiber diet, but increased DM ($P<.01$), E ($P<.09$) and CW ($P<.07$) digestibility of the high fiber diet. Fiber increased ($P<.05$) fecal nitrogen (FN), whereas virginiamycin supplementation depressed ($P<.05$) FN. Dietary treatments had no significant effects on N digestibility or N retention. Virginiamycin supplementation appears to improve the digestibility of a high fiber diet, but had little effect on a low fiber diet.

SIMULTANEOUS ESTIMATION OF TREE TAPER AND MERCHANTABLE VOLUME IN LOBLOLLY PINE. D. D. Reed* Dept. of Forestry, Va. Polytech. Inst. and State Univ., Blacksburg, VA 24061.

Compatible equations for predicting individual tree taper and merchantable volume can be fit simultaneously by defining the loss function F:

$$F = \Sigma\ (d - \hat{d})^2/\hat{\sigma}_d^2 + \Sigma\ (v - \hat{v})^2/\hat{\sigma}_v^2$$

where d and $\hat{d}$ are the observed and predicted diameter values, v and $\hat{v}$ are the observed and predicted merchantable volumes, and $\hat{\sigma}_d$ and $\hat{\sigma}_v$ are estimates of the standard error around each regression line. These standard error estimates can be found using the mean square error from ordinary least squares regression fit of each equation. Though slightly better fits can be achieved by ordinary least squares regression analysis for each equation, the simultaneous fitting procedure provides a numerically consistent and mathematically compatible set of equations without a significant sacrifice in terms of goodness-of-fit in either equation.

AFLATOXIN OCCURRENCE IN CORN. J.F. Reid*, J.L. Baker*, and D.H. Vaughan. Dept. of Agricultural Engineering, Va. Polytechnic Inst. and State Univ., Blacksburg, Va. 24061.

Low temperature drying methods, which may use solar heat and high airflow, have not been accepted as a standard practice in the southeastern United States because of warm humid conditions at harvest time. These conditions are ideal for the growth of Aspergillus flavus and other molds.

A computer model simulating low temperature corn drying was developed using deterministic criteria to describe aflatoxin development in corn drying. Grain drying subroutines previously developed by other researchers were coupled with conjunction statements to indicate potential aflatoxin development in the top layer of the grain. Simulations were performed for drying air temperatures between 12.8 and 40.6°C for constant relative humidities between 5 and 95% at airflow rates of 4, 8, 12, and 16 m^3/min per m^3 of corn.

Simulation results indicated a reduction in the potential for aflatoxin development by using high airflow rates in drying. Fixed temperature rises were shown to reduce the potential for aflatoxin development at high airflow rates.

CONTROL OF FACE FLY, MUSCA AUTUMNALIS DE GEER AND HORN FLY, HAEMATOBIA IRRITANS (L.) (DIPTERA: MUSCIDAE) ON BEEF CATTLE WITH ECTRIN EAR TAGS. James E. Roberts, Sr., and Joseph L. Despins, Dept. of Entomology, VPI&SU, Blacksburg, Va. 24061

The purpose of this test was to measure the effectiveness of Ectrin ear tags for the control of face fly and horn fly on beef cattle.

Two herds of beef cattle were involved in this test. The treated herd consisted of 30 Hereford beef cows with calves. The check herd consisted of 33 head of cattle (mixed breed). A pretreatment estimate of fly population was made on June 9, and the test herd was tagged on the following day, with one ear tag per ear. Twelve post-treatment evaluations were made. Horn fly populations were estimated by counting the average number of insects on 10 animals. Face fly populations were estimated by counting the average number of insects on the face of 10 animals.

Ectrin ear tags provided 100% control of the horn fly, and 54% control of face fly during the test period.

NORTHERN CORN ROOTWORM, DIABROTICA LONGICORNIS (SAY) CONTROL IN FIELD CORN WITH STANDARD INSECTICIDES. J. E. Roberts, Sr., and J. L. Despins*, Dept. of Entomology, VPI&SU, Blacksburg, Va. 24061.

Three insecticides, nine treatments were applied with a Gandy applicator (banded, in-furrow, and preplant incorporated) for sod planted field corn at planting time on May 7 and 9 in Bedford Co., Va., for the control of corn rootworms. Each treatment was replicated four times in plots 50 ft. x 4 rows (36 in. spacing). Root damage was determined by digging and washing 6 plants from the two center rows of each plot (July 9). Treatments were evaluated by a 1-10 root damage rating system (1970, Ohio). The field had a history of Furadan use. The soil type was Cecile Fine Sandy Loam and Enon Fine Sandy Loam. Rainfall for the period of June, July and August was below normal. Air temperature was above normal.

No significant differences were observed between treatments.

WHITE GRUB (FAMILY SCARABAEIDAE) CONTROL IN FIELD CORN, ZEA MAYS (L.) WITH BAS 11 I. James E. Roberts, Sr., and J. L. Despins*, Dept. of Entomology, VPI&SU, Blacksburg, Va. 24061.

Northrup King PX 79 field corn was sod-planted on May 15, on the VPI&SU Agronomy Farm, Montgomery Co., Va. The land had been in sod for several years. At the time of planting the water content of the soil was 26.25% and the pH was 6.3. A tank-mix of Paraquat, Atrazine, and Dual was applied prior to planting. Three rates of BAS 263 11 I (3.6, 2.4, 1.2 oz. ai./1000 ft.) were applied with a Gandy granular applicator on May 18 in a 7 in. band. Treatments were replicated 4 times on completely randomized plots measuring 12 ft. x 50 ft. (each plot was 4 rows wide - 36" rows). White grub populations were estimated before planting by taking 4 in. core samples over the entire treatment area. The grub population averaged 12 grubs per 4 in. core. Control was evaluated on July 23. Ten cores (4 in.), consisting of one corn root system and the associated soil, were taken from each plot (40 cores per treatment) to determine the average number of white grubs per core.

The median rate of BAS 263 resulted in a significant reduction of white grubs.

PERFORMANCE TESTING OF TWO TYPES OF POULTRY BROODERS. F. E. Robinson, H. A. Hughes and W. D. Weaver. Departments of Poultry Science & Agricultural Engineering, Virginia Tech, Blacksburg, Virginia 24061.

A conventional LP gas brooder was compared with a hoverless brooder for overall efficiency. Each brooder was tested with; 1) a standard ceramic and, 2) a new radiant which was lighter in weight. Tests were conducted with standard thermocouples and thermocouples housed in 30.5 mm black globes to measure radiant and conductive heat transfer. The thermocouples were placed directly under the center of the brooder at 0.3 m intervals to a distance of 3 m.

The conventional brooder produced higher radiant temperatures in the area below the hover with slightly lower temperatures outside of this area. The conventional ceramic radiant, when compared with the new radiant, resulted in higher radiant temperatures when tested in the hoverless brooder with little effect observed when tested in the conventional brooder.

Tests conducted with brooder heights of 0.60, 0.71, 0.81 and 0.91 m showed that raising the height of the brooder reduced the temperature below the brooder (radius of 1 m) with little effect outside this area.

Wood shavings placed on the test floor resulted in higher temperatures directly under the brooder, with lower temperatures elsewhere due to reflective effects.

VARIETAL PREFERENCE AND CHEMICAL EVALUATION OF THE TWO-BANDED JAPANESE WEEVIL, PSEUDOCNEORHINUS BIFASCIATUS. P. B. Schultz and M. D. Hendricks*. Va. Truck & Ornamentals Research Station. Virginia Beach, VA 23455.

The two-banded Japanese weevil, Pseudocneorhinus bifasciatus Roelofs, is an occassional pest of the home landscape. Azaleas are a favorite host of this weevil which is a daytime feeder that notches the leaves until only the petiole remains. The larvae feed beneath the soil surface on roots of woody plants. A heavy infestation of this insect occurred in 1981 in Franklin, Virginia. Five commonly grown azalea varieties were obtained from a Suffolk, VA. nursery and placed in an infested field. The Hino Crimson variety was selected for the insecticide evaluation and 4 insecticides were evaluated.

The Hershey Red variety had significantly less feeding than the other varieties, Hino Crimson, Tradition, Rosebud and Poukenense. Azaleas treated with Orthene 75 SP had the lowest feeding injury level but it only differed statistically from Knox Out 2 FM. The pyrethroid RE 35394 .3EC, Bendiocarb 76WP and the check had intermediate injury levels. Rainfall during the evaluation period was 4.54 inches which probably influenced the results.

EFFECTS OF CULTURAL TREATMENTS ON FIRST YEAR SURVIVAL AND GROWTH OF CONTAINERIZED PINE (PINUS SPP.) SEEDLINGS ON STRIP-MINED LANDS. S. L. Schoenholtz* and J. A. Burger. Forestry Dept., VPI & SU, Blacksburg, VA 24061

The effects of cultural treatments including ectomycorrhizal inoculation, chemical weed control, and slow-release fertilization on the survival and growth of container-grown P. strobus, P. taeda, and P. virginiana seedlings were studied on two strip-mined sites in Southwestern Virginia. One-half of the seedlings was inoculated with Pisolithus tinctorius two months prior to outplanting. A 21 g Agriform® starter tablet was placed within 10-15 cm of each seedling in one-half of the plots at planting; and glyphosate was applied to one half of each plot at intervals throughout the growing season.

The results showed that all three cultural treatments increased first year height and root collar diameter growth for the three species. P. taeda showed the greatest first year growth response to the treatments. Weed control increased soil moisture levels which may have accounted for some of the positive growth response. First year seedling survival was not significantly affected by the cultural treatments.

MICRONUTRIENT FERTILIZATION OF FLUE-CURED TOBACCO: II. COPPER AND ZINC. R. G. Leslie* and J. L. Jones*. VPI & SU Southern Piedmont Center, Blackstone, Va. 23824.

Thirteen field experiments, designed to study the effects of Cu and Zn on the yield and quality of flue-cured tobacco were conducted during 1980 and 1981 on soils and environments representative of those where the crop is grown in Virginia. Treatments applied to the soils consisted of various levels and combinations of Cu and Zn. Rates of Cu and Zn used for the field studies ranged from 0 to 1.68 kg/ha and 0 to 6.72 kg/ha for the respective micronutrients in 1980. In 1981 the rates were 0 to 6.72 kg/ha for both elements. An Appling fine sandy loam soil with the pH adjusted to range from 5.0 to 7.0 was utilized in greenhouse studies to evaluate the effect of various levels and combinations of Cu and Zn on the growth of flue-cured tobacco. Copper concentration in the soil and leaf tissue increased where the element was applied at higher rates in 1981. In 1980, phytotoxicity was observed at 3 of the 5 locations where Zn was band applied at 2.24 kg/ha. Severe toxic effects were also observed in the greenhouse with Cu and Zn rates above 4.48 kg/ha and a soil pH of 5.0. In the field studies, no significant increase in yield or value was obtained from applications of Cu or Zn.

INSECTICIDES APPLIED IN TRANSPLANT WATER FOR THE CONTROL OF INSECTS ON FLUE-CURED TOBACCO. Paul J. Semtner, S. Pied. Cntr. and Dept. of Entomology, Virginia Polytechnic Institute and State University, Blackstone, VA 23824.

Transplant-water applications of acephate, oxamyl, diazinon and lindane were evaluated for the control of the tobacco flea beetle, Epitrix hirtipennis (Melsheimer), and the green peach aphid, Myzus persicae (Sulzer), and for their effects on the yield and value of flue-cured tobacco. The treatments, included: acephate at 0.3, 0.6, 1.1, 2.2 and 4.4 kg ai/ha; oxamyl at 0.4 kg ai/ha, diazinon at 0.6 kg ai/ha and lindane at 0.03 kg ai/ha.

Oxamyl and all rates of acephate gave excellent control of adult flea beetles for the 2-week period immediately after transplanting but none of the treatments were better than the untreated check at 5 weeks after transplanting. Although diazinon and lindane were less effective than acephate and oxamyl, they were better than the check. All treatments except diazinon and lindane gave good control of green peach aphids for 6 weeks after transplanting. Acephate at 1.1, 2.2 and 4.5 kg ai/ha was effective against aphids for 9 weeks after transplanting. Acephate (1.1 kg ai/ha), acephate (2.2), acephate (4.5), oxamyl, acephate (0.6), acephate (0.3), diazinon and lindane increased yields over the untreated check (yield = 2605 kg/ha) by 48, 42, 39, 3, 32, 25, 14 and 6%, respectively.

CURRENT STATUS OF COLORADO POTATO BEETLE (LEPTINOTARSA DECEMLINEATA SAY) CONTROL IN THE MID-ATLANTIC STATES. D. W. Sherrod, J. A. Francis*, R. N. Hofmaster, and R. E. Baldwin*. Virginia Truck and Ornamentals Research Station, Painter, Virginia 23420.

Current control practices in commercial potato production involve the use of a planting time soil systemic insecticide and/or several foliar treatments. Aldicarb, and to a lesser extent, carbofuran, continue to be effective soil treatments for Colorado potato beetle and provide control through the first 10-12 weeks of the growing season. Recommended foliar insecticides which are adequate include: fenvalerate, carbofuran, and combinations of either of these two compounds with oxamyl. There is some indication that the efficacy of certain synthetic pyrethroid insecticides is slightly reduced when used in combination with the fungicide chlorothalonil. Cypermethrin and avermectin are two promising experimental compounds. Insecticide resistance is a major problem in Colorado potato beetle control and future management strategies may have to include the use of a wasp parasite, Edovum puttleri, and certain new strains of microbial insecticides.

DISPERSAL CHARACTERISTICS OF MUSK THISTLE SEEDS. Lane M. Smith* and L. T. Kok, Dept. of Entomology, VPI & SU, Blacksburg, VA 24061

The seeds of Carduus thoermeri Weinmann (musk thistle), a noxious weed pest in Virginia pastures, are adapted to wind dispersal. The seeds have an expandable pappus, which supports the seeds on air currents. Experiments were performed to find specific characteristics of musk thistle seed dispersal. One important aspect of wind dispersal of musk thistle seeds is terminal velocity. The average terminal velocity of thistle seeds with an average weight of 4mg was .422m/s (S.E. $\pm$ .054). Regression analysis gave the relationship ($Vg = 30.63W - .29$), where Vg is the terminal velocity and W the weight of the seed. The equation has a regression coefficient (r^2) of .84. Based on terminal velocity, these seeds should have a very limited dispersal. The pattern of seeds released from a single source confirmed this. The concentration of seeds deposited decreased logarithmically with increasing distance from the source. A negative logarithmic regression model had an r^2 ranging between .59 to .89 for different release trials. This regression model indicates that even at greater wind speeds the majority of seeds are deposited within 20m of the source.

UNDER-ROW TILLAGE. E.S. Smith* and D.H. Vaughan, Dept. of Agricultural Engineering, Va. Polytechnic Inst. and State Univ., Blacksburg, Va. 24061.

Subsoiling as practiced in previous years has had limited success on farms in the southeastern United States. In many cases the crop responses did not justify the extra cost of deep tillage. Because subsoiling was usually done prior to other tillage operations, recompaction occurring during seedbed preparation eliminated the potential benefits. A new practice of deep tilling, involving under-row ripping immediately ahead of planting, is receiving much attention in the Southeast.

Field test demonstrations were conducted in Virginia in 1977, 1978, and 1979 in corn and soybeans to correlate tillage practices with soil type, equipment cost and energy requirements. No-tillage practices and three primary tillage practices including moldboard and chisel plowing and disking were used with and without under-row ripping. Soil types included Sassafras and Woodstown fine sandy loams, Emporia loamy sand, Rains fine loam, and the Mayodan and Durham soils of the southern Piedmont. The depth of ripping, determined by the depth required to destroy any existing compacted soil layer, varied between 33 and 38 cm. Results indicated favorable yield responses and energy efficiencies in Emporia soils with minimal responses in other soils.

LIGHT TRAP STUDIES ON SOD WEBWORMS OF SOUTHWESTERN VIRGINIA. M.P. TOLLEY*. Dept. of Entomology, Va. Polytechnic Inst. and State Univ., Blacksburg, Va. 24061

Eleven species of sod webworm moths were collected during 1981. All species showed distinct differences in flight dates. Four of the eleven species are univoltine, three are multivoltine, and the other four are represented by less than six specimens each.

EFFECT OF PHOSPHORUS FERTILIZATION ON LOBLOLLY PINE (PINUS TAEDA L.) GROWTH TWENTY YEARS AFTER APPLICATION ON A PIEDMONT SOIL. J. L. Torbert*, and J. A. Burger. Dept. of Forestry, VPI & SU, Blacksburg, VA 24061

A loblolly pine fertilization study involving P and lime applications was established in 1959 on a Tatum silt loam, a clayey mixed thermic Typic Hapludult. Phosphorus was applied as ground rock phosphate (GRP) at 160 and 670 kg P/ha and triple-superphosphate (TSP) at 160 kg P/ha. Ground limestone, at 4.2 T/ha, was applied with and without TSP.

After 20 years, average tree height was only 13.1 m and no growth differences resulted from lime or P fertilization. Foliar P levels on control plots averaged 0.105% indicating the absence of a P deficiency. Higher foliar levels on treated plots reflected increased availability of soil P. The high rate of GRP application produced the highest foliar P levels (0.134%). In the long run, greater P availability can be derived by using GRP as opposed to TSP. At an application rate of 160 kg P/ha, foliar P levels were significantly higher for GRP treatments (0.122%) than the TSP treatment without lime (0.111%). As evidenced by titration of soil acidity, liming neutralizes approximately 2 meq/100 grams of highly reactive exchangeable Al, reducing P fixation and prolonging the availability of added P. Where TSP was applied with lime, foliar values of 0.115% were significantly greater than control levels.

THE INFLUENCE OF TESTING ENVIRONMENT ON GENERAL AND SPECIFIC COMBINING ABILITY ESTIMATES FOR DIVERSE TOBACCOS. T. R. Terrill and D. L. Conner*. VPI & SU, Southern Piedmont Center, Blackstone, VA and Philip Morris, USA, Inc., Richmond, VA, respectively.

The genetic responses of diverse Nicotiana parents and their hybrids were measured under flue-cured and dark-fired production and curing regimes. Twelve tobacco cultivars, representing flue-cured, sun-cured, dark-fired, burley, cigar filler and Maryland tobacco types and all hybrids among them were tested at the Southern Piedmont Center, Blackstone, Va. in 1980.

General Combining Ability (GCA) estimates were larger when the cultivars and hybrids were managed as dark-fired tobacco rather than as flue-cured. Specific Combining Ability estimates were also larger for two of three characters discussed when dark-fired production and curing practices were imposed. Production or testing environment did not seriously alter GCA family effects but was absolutely critical for appraisal of quality as measured by $/45.4 kg. Hybrid effects (reflective of Specific Combining Ability estimates) differed for flue-cured and dark-fired tests for each character studied. Differential responses present a major concern when evaluation of the full genetic potential of specific cultivars or hybrids is essential. A possible testing approach is discussed.

A STATISTICAL ANALYSIS OF SECONDARY PESTICIDE DATA. M. W. Varn, E. G. Rajotte, and R. L. Horsburgh. Dept. of Entomology, VPI & SU, Blacksburg, Va. 24061

Conventionally acute and residual efficacies of miticides are measured rather subjectively using pre and post spray mite counts without regard to economic thresholds. We found that the economic threshold could be easily incorporated making the evaluation more realistic. For acute effects we used a two-sided t-test (σ-unknown) to decide whether the average mites per leaf on the treated trees were depressed significantly below the economic threshold. Similarly when comparing residual effects we used a regression of mites per leaf against time after the last miticides application to predict the mean number of days for the mite population to exceed the economic threshold again. We used these tests to analyze efficacy data on fenbutatin-oxide, cyhexatin, and propargite obtained from "Insecticide and Acaricide Tests". While all three miticides appeared to have adequate acute efficacies, propargite seemed to have less residual efficacy than either fenbutatin-oxide or cyhexatin. Therefore, in order for propargite to maintain mite populations below the economic threshold it would have to be sprayed more often than the other two chemicals.

EARTH TEMPERING OF VENTILATION AIR. D.H. Vaughan and N.E. Blackwell*. Dept. of Agricultural Engineering, Va. Polytechnic Inst. and State Univ., Blacksburg, VA 24061.

Soil-air heat exchangers for preheating and cooling ventilation air for agricultural, industrial, and residential applications have recently gained popularity as energy conserving devices. Convective heat transfer in these heat exchangers has not been emphasized nearly as much as conduction heat transfer because performance has often been believed to be limited by conduction.

In May 1980, an open system, soil-air heat exchanger consisting of 35 m long, 20.3 cm diameter, non-perforated, heavy duty, repeated-rib, polyethylene drainage tubing was installed at a depth of 1.8 m at the VPI&SU Swine Research Center. A belt-driven, radial blade fan was used to draw air through the heat exchanger network. Tests were conducted during the winter, spring and summer of 1981 to evaluate heating and cooling potential of the heat exchanger. Instrumentation was used to record, at specified time intervals, temperature (soil, ambient and tube air (wet bulb and dry bulb), and tube wall), relative humidity, air flow and pressure drop. Sensible and total heat gains as a function of tube length as well as convective heat transfer coefficients were computed from the data.

STUDIES ON THE INFESTATION INTO POLYSTYRENE INSULATION BY THE LESSER MEALWORM (ALPHITOBIUS DIAPERINUS PANZ.), A COMMON MANURE INHABITANT OF DEEP-PIT CAGED LAYER HOUSES. J. A. Vaughan and E. C. Turner, Jr., Entomology Dept., Virginia Polytechnic Institute & State University.

Alphitobius diaperinus (Panz.) are often found in very high numbers in the manure of deep-pit caged layer houses and may become structural pests in some houses by boring into and subsequently destroying polystyrene wall panels used to insulate these houses.

Five stock colonies were gathered from a deep-pit poultry operation in Amelia Co., Va. In order to follow the successive tunneling and infestation into polystyrene by A. diaperinus, panels of insulation were placed into the stock colonies, periodically removed and sectioned, and the number and lifestage of A. diaperinus recovered from each panel were counted and recorded. The test was conducted for 35 days.

Late instar larvae were found to initiate tunneling. During the first ten days adult females used the polystyrene surfaces for ovipositional sites, however the resulting early instars did not stay on the panels. Fifteen to twenty days post-introduction adult beetles moved into the polystyrene whereupon the presence of other lifestages declined.

USE OF CHRYSOPA SPP. FOR PEST CONTROL IN NORTHERN CHINA. Ren Wang* and L. T. Kok. Dept. of Entomology, Va. Polytechnic Inst. and State Univ., Blacksburg, VA 24061

Chrysopa spp. play an important role in the biological control of cotton and fruit tree pests in mainland China. Twelve species of Chrysopids have been recorded in the country, with five species being dominant in the north. Since 1974, studies on the biology and population dynamics of Chrysopids, especially C. sinica Tjeder, have been conducted. Factors influencing the population in cotton fields were studied in Hubei province. In addition, experimental field and greenhouse releases of C. sinica were shown to be quite successful and effective in controlling Heliothis spp., Tetranychus spp., Trialeurodes spp. and various aphids. Techniques for mass rearing the chrysopids have been developed satisfactorily; eggs of the rice moth, Corcyra cephalonica, are used as chrysopid larval food source in the laboratory, while mass propagation of the moth has been conducted in Peking and two other provinces. Progress has been made on the study of synthetic diet and artificial eggs for the larvae. However, many problems and questions about the practicality of releasing the chrysopids for pest control in China still remain. Currently, attention is on integration of mass release, and conservation of the natural populations of the chrysopids.

FLEXURAL STRENGTH OF POULTRY LIMB BONE. J. H. Wilson* and J. L. Baker*. Dept. of Agricultural Engineering, Va. Polytechnic Inst. and State Univ., Blacksburg, Va. 24061.

Investigators have long recognized the need to determine the mechanical properties of animal limb bones. These tests have been conducted not only for the purpose of determining the normal mechanical strength of bone but also for the purposes of determining the strength of bone as an end point in experimental biochemical and endochrinological programs. The need for such tests is especially prevalent when investigating such phenomena as fracture healing, dietary, metabolic, or endocrine alterations in animal bone.

The objectives of this investigation were to develop a test procedure for evaluating the strength of avian bone (that could be used by the poultry industry) and to evaluate the influence of protein level and the effect of juvenile nutrition on bone strength. The experimental program consisted of three series of three-point bending tests, within the elastic range of the bone. In two of the test series (humerus, ulna, radius, femur, tibiotarsus, and tarsometatarsus) beam lengths of 25.4 mm and 50.8 mm were used. The third series (tarsometatarsus) had a beam length of 76.2 mm. The average modulus of elasticity from these tests is 22 GPa.

HYDROGEN AS A FUEL FOR AGRICULTURE. J.H. Wilson*, D.H. Vaughan, H.A. Hughes* and J.L. Baker*, Dept. of Agricultural Engineering, Va. Polytechnic Inst. and State Univ., Blacksburg, VA 24061.

The primary cost involved in a hydrogen energy system is the initial capitalization for the equipment and facilities. Generating equipment and storages must be provided. Equipment must be modified to use hydrogen as an energy source. Increased risk, resulting from operational and economic uncertainties, must be carefully evaluated and balanced against the obvious benefits of a fuel which can be manufactured on the farm from water, one of the most common materials on earth.

Hydrogen can be stored as a gas, liquid, or as a metal hydride. Gaseous hydrogen must be compressed (14MPa) and stored as a high pressure gas and must be used near the source. Liquid hydrogen storage is undesirable because it takes a large fraction of the available energy to liquefy the gas at -253°C. Metal hydride may be the most practical alternative for agriculture. Hydrogen is stored or removed in a reversible chemical reaction ($M+H_2 \leftrightarrow MH_2$).

Hydrogen can be generated using electrolysis, off-peak electricity or windmill generated power. The overall conversion efficiency is approximately 75%. Electrolysis uses about 4.5 kW of electricity to produce one m^3 of hydrogen which may be burned like LP gas.

DEVELOPMENTAL EFFECTS OF DIFLUBENZURON ON THE MEXICAN BEAN BEETLE, AND THE LARVAL PARASITE, PEDIOBIUS FOVEOLATUS. P. A. Zungoli,* Dept. of Entomology, VPI&SU, Blacksburg, Va. 24061, A. L. Steinhauer*, and J. J. Linduska,* Dept. of Entomology, Univ. of MD, College Park, MD 20742

The developmental effects of diflubenzuron, an insect growth regulator, on the Mexican bean beetle, Epilachna varivestis Mulsant (Coleop.:Coccinellidae) and the larval parasite, Pediobius foveolatus (Crawford) (Hymenoptera: Eulophidae), were examined in laboratory and field tests. Laboratory tests showed that the compound, at concentrations of 0.01%, 0.10%, and 1.0% active ingredient, had no significant effect on parasite oviposition, fecundity, emergence rate, or developmental time when topically applied to either adult parasites prior to oviposition, or to parasitized Mexican bean beetles 10 days after oviposition ($p<0.01$). Profound interference of parasite development does occur when diflubenzuron is applied to Mexican bean beetle larvae 4 days after parasite oviposition ($p<0.01$). In the field study, 3 rates of diflubenzuron at 0.018 kg AI/ha, 0.053 kg AI/ha, and 0.088 kg AI/ha were tested along with carbaryl at 1.12 kg AI/ha. A control was included. Five replicates of each were conducted. Diflubenzuron gave ca. 70% control of the Mexican bean beetle, and carbaryl gave ca. 83% control. Parasite emergence was not significantly different ($p<0.01$) in diflubenzuron and carbaryl treated plots.

Astronomy, Mathematics, and Physics Section

RECENT ADDITIONS TO AN OLD DEMONSTRATOR'S NOTEBOOK. D. Rae Carpenter, Jr. and Richard B. Minnix. Dept. of Physics, Va. Military Inst., Lexington, VA 24450

We are fortunate in having an annual infusion of new demonstration ideas from the participants in our summer short courses on physics demonstrations.

Sister Lynne Parrott of Covington, KY, shared with us two free fall demos which are the ultimate in simplicity, using styrofoam cups. Two small brass weights hooked over the edge and held by a rubber band to the bottom of the cup, will jump inside when dropped (the band's pull is no longer balanced by the weight in free fall). Water draining from a hole or holes in the side wall of another cup ceases to flow when falling because there is no longer a pressure due to the weight of fluid.

George Vanderkuur of the Ontario Science Centre showed us how to support a heavy man with a plastic garbage bag blown up by a vacuum cleaner. He also stands on an egg placed on end in a bed of sand. This latter apparatus must be made in a shape to apply the force to the egg precisely and uniformly.

THEORY OF SLOW ATOMIC COLLISIONS. J. B. Delos, Physics Dept., College of William and Mary, Williamsburg, Va. 23185

The quantum theory of slow atomic collisions has long been beset by fundamental difficulties. The formulation given by Mott in 1933 was based upon an extension of the Born-Oppenheimer description of molecular states, in which the fast-moving electrons adjust almost adiabatically to the fields of the slow-moving nuclei. It has been known for many years that this formulation leads to strange and non-physical results, such as infinite range interactions between atoms.

We have identified the source of these difficulties, and we have reformulated the theory to remove them. The standard formulation invokes waves which, instead of propagating perpendicular to their crests, slip a bit sideways. Real atomic waves do not do this. We have shown that, by using a description involving curved wave-fronts, or superpositions or crossing wave-trains, the difficulties of the theory are removed.

We illustrate the theory with calculations on collisions of protons with Hydrogen atoms.

CLASSICAL AND QUANTUM THEORIES OF ATOMIC AND MOLECULAR SYSTEMS. J. B. Delos, R. T. Swimm and S. K. Knudson, Physics & Chemistry Depts., College of William and Mary, Williamsburg, Va. 23185.

In the past 15 years, rather surprising properties of classical mechanical systems have been found. All separable systems display what is called "regular" or "multiply-periodic" motion. Non-separable systems, however, display a very irregular type of motion. The existence of these two types of motion in classical mechanics suggests that there might be two distinct types of behavior in quantum mechanics.

We have made calculations on oscillator systems and on atoms in a very strong magnetic field. Results of these calculations will be displayed.

SOFT X-RAY EMISSION SPECTROSCOPY AT THE UNIVERSITY OF VIRGINIA. C. Franck, F. Zutavern, S. Schnatterly, D. Husk, D. Carson and T. Aton, Department of Physics, University of Virginia, Charlottesville, VA 22901

The measurement of soft x-ray emission spectra is improving our understanding of electrons in solids. In our recently completed spectrometer targets are excited to emit soft x-rays with a beam of low energy (100-3000 eV) electrons. The emitted radiation is analyzed over the energy range 20-800 eV using four toroidal (holographically ruled) grazing incidence reflection gratings and a novel multichannel detector.

With this instrument we have recently studied the effect of disorder on the conduction band density of states by observing the spectra of crystalline and amorphous silicon samples. Another sample which has been studied in single crystal graphite. By measuring the x-rays emitted at different angles from the sample contributions from different bonding orbitals can be understood in this layered compound.

A STUDY OF L726-8. L.W. Fredrick and J. Rohde. Dept. of Astronomy, Univ. of Virginia, Charlottesville, Va. 22903

This unusual system, discovered by W. Luyten in 1949, contains the prototype flare star-UV-Ceti-as its B component. Two hundred forty-one plates taken between 1949 and 1982 yield an orbit and masses for the system. The parallax (+0.378) and proper motion ($3''.328$/yr in $80°.1$) agree within the errors with a study by Harrington. Our period, orbital elements, and masses differ from those of Harrington probably because we have ten more years of observations and hence have covered one complete orbit. Our provisional results yield a period of $24^{y}.78$ and masses of 0.11 $M_{\odot}$ and 0.08 $M_{\odot}$. This makes UV Ceti one of the least massive known stars. This work is partially supported by NSF Grant AST 79-21542 -01.

MAGNETIC CIRCULAR DICHROISM OF COPPER PROTEINS. Bernard S. Gerstman and Arthur S. Brill, Dept. of Physics, Univ. of Va., Charlottesville, VA 22901

The application of a magnetic field supplies a "handedness" when applied to a medium and breaks any chiral symmetry in the absorption of circularly polarized light passing through the medium. This magnetic circular dichroism (MCD) is valuable in obtaining information on the electronic states of molecules. We are applying MCD techniques in the study of blue copper proteins, specifically azurin which is part of a bacterial respiratory system.

The physical basis for the magnetically-induced circular dichroism will be briefly explained in terms of the effect of the magnetic field on the electronic quantum states of the molecule.

A quantum mechanical model for the cupric site in azurin has been developed from absorption, EPR and circular dichroism measurements. With such a model an MCD spectrum can be calculated which depends on energy differences, electronic dipole matrix elements and magnetic dipole matrix elements between electronic states of the copper. The experimentally measured MCD spectrum can then be used to test and refine the model by adjusting the electronic energy level differences and symmetries to fit the MCD data, within limits set by the other types of data used to construct the model.

Research supported by the National Science Foundation.

RECENT DEVELOPMENTS IN THE APPLICATION OF MUON SPIN ROTATION (μSR) TO PROBLEMS OF THE SOLID STATE*. W. J. Kossler, College of William and Mary, Williamsburg, Virginia 23185

The positive muon has the same electronic structure as hydrogen and thus is able to serve as a test probe for hydrogen-solid interactions. Among the problems which can be studied are: the hydrogen motion, site selection, trapping, and hyperfine fields. Several techniques will be reviewed. A new source of muons at Brookhaven National Laboratory will also be discussed.

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DEVELOPMENT OF AN INERTIAL CLOCK USING MACROSCOPIC ROTORS.† Carl H. Leyh,* Univ. of Va., Charlottesville, VA 22901.

In a suitable drag free, noise free environment, a spinning rotor can be used as an ultra high Q inertial clock. This clock when used in conjunction with other clocks of a fundamentally different time keeping mechanism could be used to test the non-metricity of general relativity.[1] The corotation of a "shroud" cylinder with a "proof" rotor freely spinning inside it provides such an environment by virtually eliminating gas drag, and could considerably reduce magnetic torsional effects, on the "proof" rotor. A corotation system is now operational in the lab[2] using a "shroud" cylinder that is servo-controlled to mimic the rotational motion of the inner "proof" rotor. This control of the protecting outer cylinder is provided by a microprocessor-commanded, eddy current drive servo-loop. The operational parameters and experimental results of the system at atmospheric pressure will be presented and future improvements of this apparatus will be discussed, along with plans for a possible cryogenic apparatus.

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LOW COST DIGITAL DATA ACQUISITION SYSTEM FOR FREE DECAY OF STANDING WAVES IN CONTINUOUS MEDIA

R. W. Meredith and A. J. Zuckerwar

A low cost digital data system based on an 8-bit Apple II microcomputer has been designed to provide on-line control, acquisition, and evaluation of sound absorption measurements in gases. The measurements are conducted in a resonant tube in which an acoustical standing wave is excited in the tube, the excitation removed and the sound absorption evaluated from the free decay envelope. The microphone response to the sound pressure level is the source of the analog data for the digital system. This presentation will describe the measurement, digital hardware, software and system performance. Also, measurements of sound absorption in air will be presented as an example.

Old Dominion University Research Foundation Norfolk, VA · 23503

LOOKING AT NUCLEI WITH ELECTRONS. Blaine E. Norum, Dept. of Physics, Univ. of Va., Charlottesville, Va. 22901.

Electrons have long been recognized as an ideal tool for probing nuclei. Studies of the scattering of highly energetic electrons from nuclei have made tremendous contributions to the foundations of both elementary particle physics (via the first direct evidence of the existence of quarks) and nuclear physics (via the most accurate determinations of nuclear sizes and shapes). To extend this work requires a new electron accelerator capable of delivering high energy, high intensity, continuous beams of electrons. Such an accelerator has been proposed by the Southeastern Universities Research Association. The accelerator consists of a pulsed linear accelerator that delivers electrons to a storage ring from which they are extracted in continuous beams. As well, the design is extremely flexible and will provide facilities for solid state physics and chemistry research, industrial application, and medical uses (clinical, diagnostic, and research). Upon completion the laboratory will rank among the world's foremost research centers.

SUPERCONDUCTIVITY IN PALLADIUM ALLOY HYDRIDES. A. Rex*, J. Ruvalds* and B. Deaver. Dept. of Physics, Univ. of Va., Charlottesville, Va. 22901

Pure palladium has been found not to be a superconductor at temperatures as low as 2×10^{-3}K. The primary reason for this is that palladium is strongly paramagnetic at low temperatures ($X \simeq 7 \times 10^{-6}$ cm^3/g). When palladium is "demagnetized" by introducing structural defects, it exhibits a superconducting transition temperature (T_c) of about 3K. The technique of low temperature ion implantation is used to introduce hydrogen or deuterium into a fixed palladium film. The transition temperature can be increased to 9K or 11K by introducing hydrogen or deuterium, respectively, in a H(D)/Pd ratio of about 1.0. By adding post-transition metals (e.g. Cu, Zn, Al) to the palladium-hydride (deuteride) system, the transition temperature can be increased further, to a maximum of $T_c \simeq 16$K for $Pd_{.55}Cu_{.45}H_{.70}$. (Research supported by NSF Grant No. DMR78-25791).

CLOSE-UP OF A STAR - OUR SUN. Elske v.P. Smith, Virginia Commonwealth University, Richmond, Va. 23284

The Sun is a very ordinary, average star, but our proximity to it allows us to examine it in detail. A handful of stars have been resolved into disks by use of special techniques, by interferometery, but only for the sun can we directly discern surface features and the distinctive characteries of the atmosphere layers.

The term "solar activity" includes a wide variety of phenomena, such as sunspots, flares, prominences, and coronal streamers. These are all in some manner controlled by magnetic fields and follow the eleven (11) year solar cycle. Whether such activity actually causes a variation in the total output from the sun has been a matter of controversy and uncertainty for many years. Recent data obtained by the Solar Maximum Mission indicate that the sun does vary by a few tenths of a percent on a time scale of days, (R.C. Wilson and H.S. Hudson), Astrophysical Journal, 244, L 184, 1981).

The relation between solar variability, in particular, solar activity, and terrestrial climate has been till recently a subject on the periphery of serious scientific study. Only in the last few years has it been "respectable" to suggest that there is such a relationship. Jack Eddy has shown to the satisfaction of many that the earth's climate has changed to the extended presence or absence of sun spot.

MICROWAVE PROPERTIES OF SUPERCONDUCTING NIOBIUM NITRIDE MICROBRIDGES. R. L. Steiner*, and B. S. Deaver, Jr. Dept. of Physics, Univ. of Va., Charlottesville, Va. 22901.

A series of NbN thin film microbridges with transition temperatures ranging from 5K to 14K incorporated into bulk NbN rings, are being characterized by microwave measurements at 9.6 GHz. The devices are nominally 1 μm long, 10 nm thick and from 1 μm to ~ 50 μm wide and are fabricated on 1 mm-diameter quartz rods. Information is being found about each device critical current, resistance, energy sensitivity and performance as a Superconducting Quantum Interference Device (SQUID) as a function of temperature, along with studies relating these properties to the granular nature of the microbridges. Also low power measurements are being made, examining the impedance as a function of phase to determine the current-phase relation and to search for the cos ϕ interference term. (Research supported by ONR contract No. N00014-81-K-0400).

MAGNETIC FIELDS AND SPONTANEOUS NEUTRON-ANTINEUTRON TRANSITIONS. Nikola Zovko and W. Peter Trower, Dept. of Physics, VA Tech, Blacksburg, VA 24061.

The effect of a constant plus time periodic magnetic field on neutron-antineutron oscillations is considered. The underlying selfadjoint system of linear differential equations and the corresponding Hill's equation are studied. An approximate analytic solution is found for all times. By optimizing the growth of the antineutron probability, two free parameters of the driving field are determined automatically.

THE MAGNETIC ENVIRONMENT OF POSITIVE MUONS IN DILUTE IRON ALLOYS. C. E. Stronach and K. R. Squire*, Va. State Univ., A. S. Arrott* and B. Heinrich*, Simon Fraser Univ., W. F. Lankford, George Mason Univ., W. J. Kossler*, Col. of Wm & Mary, and J. J. Singh, NASA Langley Research Center.

The average magnetic fields, B_μ, observed by μ^+ in Fe alloys were measured using the standard μ^+SR technique with zero applied magnetic field, and the contact hyperfine fields, B_{hf}, were calculated from these measured values. Fe alloyed with Aℓ,Ge,Ti and Nb was studied over a range of temperatures, while alloys with N,Si,V,Cr,Mn,Co,Ni and W were studied at room temperature only.

The fractional change in B_{hf} was positive only for Co and was zero for Ge. Shifts were negative, but less than expected for simple dilution, for Cr,Aℓ, Si and Mo. W,V and Mn approximate simple dilution, while Ti,Ni and N decrease B_{hf} much more than simple dilution predicts.

The variation in the fractional change of B_{hf} with temperature indicated that μ^+ are repelled by Aℓ impurities and attracted by Mo impurities. The study of the Fe + Fe_2Nb two-phase alloy implies weak trapping of μ^+ about Fe_2Nb inclusions and, in conjunction with other observations, suggests that the presence of strain in samples generally lowers the magnitude of B_μ. (Aided by NASA grant NSG 1342.)

COLLISIONS OF NEGATIVE IONS WITH ATOMS. R. D. Taylor, T. S. Wang and J. B. Delos, Physics Dept., College of William and Mary, Williamsburg, Va. 23185

We consider electron detachment in slow collisions between negative ions and atoms, $A^- + B \rightarrow A + B + e^-$, at collision energies of 1-200 eV. A general theory of this process has been developed. The mathematical framework involves the solution to a non-denumerably infinite set of coupled equations. It is shown that under reasonable and general assumptions, this equation can be reduced to a tractable form and solved. Cross-sections have been calculated for H^- or D^- colliding with He or Ne. An interesting aspect is the observed isotope effect. For the He target, D^- gives more detachment than H^-, while for the Ne target, the opposite effect is found.

PROTON TIMELIKE FORM FACTORS AND RECENT $e^+e^- \gtrless p\bar{p}$ DATA. W. Peter Trower and Nikola Zovko, Dept. of Physics, VA Tech, Blacksburg, VA 24061.

We present an analysis of recent $e^+e^- \gtrless p\bar{p}$ data in an extended vector dominance model which has usual analyticity properties and a rather weak asymptotic boundedness condition. The model allows the necessary analytic continuation into the annihilation region. The few free parameters are determined by the fit to the world's data. As expected, the scarce time-like data place a strong constraint on the analysis, causing in the variants we considered, the time-like form factors, to develop a large imaginary part.

MAGNETIC CONFINEMENT TIME MEASUREMENTS. K. D. Womble* and G. R. Taylor. Dept. of Physics, James Madison University, Harrisonburg, VA. 22807

The magnetic confinement time of the primary ionizing electrons is a very important parameter in understanding the production of plasma in multidipole devices. Measurements of the magnetic confinement time in a small 7.5 ℓ multidipole system will be reported. In an argon plasma in that system, the magnetic confinement time was found to be approximately 1 μ sec by two different experimental methods.

A TWO-BEAM OPTICAL INTERFEROMETER FOR EXAMINATION OF VIBRATING DIAPHRAGMS. Kenneth L. Yates* and William C. Sauder, Dept. of Physics, Va. Military Inst., Lexington, VA 24450

We describe a two-arm Dyson polarization interferometer for characterizing the diaphragm vibration of ultrasonic transducers. The reflecting element in each arm is a cat's eye retroreflector formed by a mirror placed in the focal plane of a converging lens. The cat's eye mirror in one arm of the interferometer is the transducer diaphragm under investigation. Lock-in sensing of quadrature signals from the interferometer permits mapping of both the amplitude and phase of vibration at all points on the transducer face.

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Bio. 1

THE MOUSE AS A MODEL FOR HUMAN IN VITRO FERTILIZATION. Peter J. Adams, Steven B. Ackerman, R. James Swanson, J. W. Edward Wortham, Jr. Andrology Laboratory, Dept. of Biological Sciences, Old Dominion University, Norfolk, Va. 23508

Success rates of superovulation in response to gonadotropic hormone treatment and in vitro fertilization (i.e., mitotic cleavage following insemination) of mouse eggs from outbred CD-1, hybrid $CB6F_1$, or hybrid $B6CBAF_1$ mice were compared using either a mouse insemination medium, modified Krebs-Ringer-bicarbonate (m-KRB), or a human insemination medium, Ham's F10 nutrient mixture. Insemination in either organ culture Petri dishes or screw-top, flat-side tissue culture tubes was also examined. Mean superovulation rates ($\pm$ S.D.) were 24.2 (5.1) for CD-1, 33.0 (5.8) for $CB6F_1$ and 16.3 (6.6) for $B6CBAF_1$ mice. For in vitro cleavage the best combination of mouse strain, insemination medium and culture container was achieved using $CB6F_1$ mice, m-KRB medium and culture tubes. However, Ham's medium used with either hybrid mouse strain was shown to be employable for fertilization of mouse in vitro as a quality control assay and/or experimental model system for testing the human in vitro fertilization procedure.

Bio. 2

THE BIOLOGY OF HUMAN STRESS WITH NEW ANALYSES OF ITS CAUSATION WITH PSYCHOPHYSIOLOGIC (PSYCHOSOMATIC) DISORDERS. John C. Bartone. American Health Research Institute, Annandale, Virginia 22003

Biologists with their overall perspectives on the realm of organisms and human existence must help explain causations, analyses, prevention and cure of human stress. Stress and its manifestations and unlimited varieties creates more havoc in world populations than any group of diverse entities. The science and medical literature of stress is exponential growth without sufficient practical solutions.

Several new theories are presented to suggest the formation of new destiny for biological thoughts in order to re-direct analysis and typology of human personalities to effectuate elimination or less stress thereby improving quality of life and behavior. Life without a continuum of biologic philosophy cultivates and harbors stress and resultant psychosomatic disturbance with psychophysiologic (organic) disorientation.

Bio. 3

ASSESSMENT OF DAMAGE TO THE AQUATIC COMMUNITIES IN SEVERAL STREAMS RESULTING FROM AN OIL SPILL, M. L. Bass, Dept. of Biol. Sci., Mary Washington College, J. R. Voshell, Jr., Entomol. Dept., and R. W. Young, Biochem. Dept., VPI&SU.

In March 1980 two simultaneous breaks in Colonial Pipeline Co. refined products line in Northern Va. spilled approx. 6,130 bbls. of #2 fuel oil into Mine Run Creek and approx. 8,000 bbls. of kerosene into Bull Run Creek. Damage to these streams was assessed by water chem., sediment TCO, periphyton and macrobenthic community analyses. Periphyton samples were taken using a bar-clamp sampler and analyzed by cell counting. Bacteria population was analyzed by standard plate count. Macrobenthos was sampled with a PIBS and D-frame net kick sampler. After the macrobenthos identification and enumeration they were sorted into trophic functional groups. The biomass of macrobenthos and periphyton was reported as AFDW. The effects of the oil spill were most evident in Mine Run with reduced standing crop, density, $\bar{d}$, and taxa no. The collector-filter group was reduced while collector-gatherers and scrapers were more abundant at the affected sites. There was no clear evidence of long term adverse impacts to the macrobenthos in Bull Run Creek. Low $\bar{d}$ of the periphyton community in Mine Run indicates continued pertubation. Increased bacteria biomass correlated with the increased scrapers at impacted stations. Diatoms were dominant periphyton in the streams in 1980 and 1981.

Bio. 4

CAFFEINE AND AFLATOXIN SENSITIVITIES IN DROSOPHILA MELANOGASTER. David Bettinger, Robert Gogal, Deborah Mills, and Joseph P. Chinnici. Dept. of Biology, Va. Commonwealth Univ., Richmond, Va., 23284

Natural populations of D. melanogaster from Virginia display a wide range of sensitivity to the toxic effects of both caffeine and aflatoxin B_1 (AFB_1). In addition, caffeine appears to protect larvae from the toxic effects of AFB_1 fed either subsequent to or simultaneous with caffeine feeding. Larvae from natural strains were fed caffeine (1×10^{-2}M) for the first 48 hours of development (second instar stage). The larvae then were transferred onto AFB_1 media (0.5 and 1.0 PPM) and allowed to complete development as adults. Larvae from the same strains were grown, in a second experiment, on a mixture of caffeine (1×10^{-2}M) and AFB_1 (1.0 PPM). In general, a protective effect, due to the presence of caffeine in the diet, was detected in both experiments. Egg-to-adult mortality was far greater when the diet contained AFB_1 alone than when both caffeine and AFB_1 were together in the diet.

Bio. 5

STUDIES OF THE BEE FLY, ANTHRAX ANALIS (BOMBYLIIDAE), PARASITIC ON TIGER BEETLE LARVAE (CICINDELIDAE). A. L. BRAM AND C. B. KNISLEY. Dept. of Biology, Randolph-Macon College, Ashland, VA 23005.

Surveys of third instar tiger beetle larvae in eastern Virginia revealed parasitism rates by A. analis of 78% for Cicindela tranquebarica, 48% for C. scutellaris, 11% for C. hirticollis and 9% for C. marginata. No parasites were found on C. repanda, C. dorsalis, C. punctulata and Megacephala virginiana. Size, seasonal cycle and habitat of the host may explain these differences. Mean parasite loads were 6.1 for C. tranquebarica and 3.4 for C. scutellaris. Preferred attachment sites were on the thoracic sterna and also for C. scutellaris, under the head capsule. C. tranquebarica larvae with heavy parasite loads (11-15, 16-20, >20) had significantly higher parasite and host mortality and lower parasite growth than hosts with low parasite loads (1-5, 6-10). Parasite mortality is high for all groups. Limited observations suggest only one parasite can complete development on each host larvae. Parasite growth was low before and during but increased rapidly after host diapause. These results suggest that parasitism by this species is a major selective force on some larval tiger beetle communities.

Bio. 6

DISPERSION OF GERMAN COCKROACHES, BLATTELLA GERMANICA (L.), WITHIN A SIMULATED HARBORAGE. B. L. Bret. Dept. of Entomology, VPI & SU, Blacksburg, VA 24061

German cockroaches gather in secluded harborages, where aggregations of mixed age classes are formed. However, little is known about behavioral interactions within such groups. A laboratory experiment was designed to study aggregation within groups consisting of adult males, adult females, and middle and early stage nymphs. Each group was allowed to disperse in an acquarium in which a harborage area consisting of 4 side-by-side shelters was provided. Two variables were used: female density and female reproductive state. Data collected from censusing the occupants of each shelter were analyzed by a dispersion statistic. Values of the statistic indicated whether random dispersion or aggregation occurred. The results showed an inter-relationship between the effects of female reproductive state and female density on the aggregating behavior of both the specific components of the group and on the group as a whole. For example, when egg case-bearing females were used, aggregation increased with density; when non-gravid females were present, aggregation decreased with density. Also, overall aggregation was more intense when females carried immature oothecae than when oothecae were close to hatch. Underlying such effects were differences in intra- and inter-component aggregation behavior. These are described and discussed in terms of survival and reproductive success.

Bio. 7
EFFECTS OF ETHOSUXIMIDE TREATMENT ON BEHAVIOR, REPRODUCTION, AND NEONATAL MOTOR DEVELOPMENT IN CD-1 MICE. Paul A. Britt* and Arthur F. Conway, Dept. of Biology, Randolph-Macon College, Ashland, Va. 23005.

Fifteen mating pairs of CD-1 outbred mice were maintained as follows: 5 pairs received tap water, 5 pairs received 50 mg/ml ethosuximide in tap water, and 5 pairs received 100 mg/ml ethosuximide in tap water as their only source of drinking water. Solutions were replaced every 18 to 24 hours. Mice were observed for behavior and delivery of offspring every 12 hours. Behavior of the adults was evaluated using an aggressiveness rating of 1 to 10. Motor coordination of the offspring was evaluated using a glass rod agility test applied every other day from one to three weeks postpartum. At the termination of the experiment the reproductive status of the adults was evaluated by autopsy. Ethosuximide treated adult mice exhibited either greatly increased aggressiveness or increased lethargy as compared to the controls. Ethosuximide treated mice produced fewer and smaller litters than did the controls. The reproductive tracts of ethosuximide treated male mice did not differ from those of control males. The reproductive tracts of ethosuximide treated female mice exhibited a higher incidence of fluid accumulation in ovarian capsules, swollen uteri, and resorbed embryos than did those of control females. Offspring of treated females showed significantly reduced agility compared to controls in the agility test.

Bio. 8
HABITAT CHOICE AND COMPETITION IN THREE TROPICAL LITTORAL ZONE SNAILS, NERITA TESSELLATA, N. VERSICOLOR, AND TECTARIUS MURICATUS. Luther Brown and Kristine R. Hackett*. Dept. of Biology, George Mason Univ., Fairfax, Va. 22030

Vertical zonation is a common phenomenon in intertidal communities. Such zonation typically involves habitat segregation between species, and may involve size gradients within species. The causes of vertical zonation remain a matter of debate. We examined zonation in a intertidal snail community on the east coast of Andros Island, Bahamas. This community is composed of only three species, each of which occupies a more or less discrete part of a homogeneous rock shelf. Size gradients were apparent in each species, nerites decreasing in size at the upper limits of their range, periwinkles (Tectarius) increasing in size. Manipulative studies revealed that both inter- and intra-specific distribution patterns were caused by habitat preferences. Our experiments suggest that dessication, drowning, wave action, exposure, predator pressure and direct competition were not immediate causes of the observed distribution patterns. We conclude that distribution patterns reflected feeding sites and foraging patterns of the three snails.

Bio. 9
HOME RANGE MOVEMENTS IN THREE SPECIES OF TROPICAL LITTORAL ZONE SNAILS. Luther Brown and Carol Herron*. Dept. of Biology, George Mason Univ., Fairfax, Va. 22030

Movement patterns may be important determinants of the vertical habitat zonation frequently observed in gastropod communities. We examined the daily movements of approximately 100 individual snails in each of three species, Nerita tessellata, N. versicolor and Tectarius muricatus which compose an intertidal snail community on the east coast of Andros Island (Bahamas). All three species showed regular daily movement during our 11 day study. Frequency distributions of distance moved were characteristically leptokurtic, suggesting that some members of each species moved relatively large distances, while others were more sedentary. While distances moved horizontally depended on local topography, N. tessellata and T. muricatus moved approximately 1m/d. Home range maps demonstrate that N. versicolor wandered extensively and had no discrete home area. Both of the other species tended to move within very confined areas, and have distinct home ranges.

Bio. 10

STUDIES OF THE OFFSPRING OF IMMUNE STIMULATED MICE. Jeanie L. Bryant*, Carolyn M. Conway, Dept. of Biology, Va. Commonwealth Univ., Richmond, Va. 23284, and Arthur F. Conway, Dept. of Biology, Randolph-Macon College, Ashland, Va. 23005.

Maternal immune stimulation of CD-1 mice was achieved by subcutaneous injections of thyroid homogenate- or saline-Freund's adjuvant emulsions. Immunized and control females were mated 4 weeks following initial immunization. The effects of immune stimulation on embryonic development was examined on days 9-13 of gestation. Embryos with craniofacial abnormalities and reduced crown-rump lengths were found among the offspring of 13 of the 15 immune stimulated females (both thyroid-specific and non-organ specific). No abnormalities were observed in the offspring of 7 control females (saline-injected and uninjected). The highest incidence of abnormal embryos occurred among the offspring of thyroid-incomplete Freund's adjuvant injected females. The average crown-rump length of morphologically normal embryos of thyroid immunized females was reduced as compared with control offspring. The occurrence of smaller embryos and abnormal embryos among the offspring of immune stimulated females suggests a correlation between maternal immune response and an alteration of morphogenesis and growth during early organogenesis. It is hypothesized that the proliferation and growth of embryonic cells is retarded as a result of the maternal immune stimulation. (Supported by the NSF-URP Program at Va. Commonwealth Univ.)

Bio. 11

QUANTITATIVE RELATIONSHIP OF UREAPLASMA UREALYTICUM TO SEMEN PARAMETERS. Rebecca D. Cintron, J. W. Edward Wortham, and Jeannine F. Whitmyer*. Dept. of Biological Sciences, Old Dominion Univ., Norfolk, Va. 23508.

Recent reports suggesting an association between Ureaplasma urealyticum and and unexplained infertility remain controversial. The purpose of this study was to quantitatively assess the effect of U. urealyticum on seamen parameters and to determine if the standard currently applicable to significant bacteriuria might also be applied to semen. One hundred eighty-eight semen samples from men under examination for suspected infertility were examined in this study. Eighty-five of the specimens cultured positive for U. urealyticum. Colony forming units were determined by standard plate dilution techniques using Shepard's medium A-7. The range of numbers of U. urealyticum from the positive samples was $2.0 \times 10^{1} - 6.0 \times 10^{5}$ organisms/ml of semen. Both positive and negative specimens had average counts and volumes within normal limits. Regression analysis of semen parameters revealed that increasing titers ($>10^{4}$ organism/ml of U. urealyticum positive samples were inversely related ($p<0.05$) to semen volume. Higher titers were not found to significantly affect sperm motility or morphology. The number of morphologically normal sperm appear greater in U. urealyticum positive specimens; however, no statistically significant difference was detected.

Bio. 12

SUBNIVEAN ACTIVITY PATTERNS OF THE LONGTAILED VOLE (MICROTUS LONGICAUDUS). Jack A. Cranford, Biology Dept., Virginia Polytechnic Institute, Blacksburg, Va. 24061.

Longtailed vole activity and movement patterns were studied at 2900m in Albion Basin, Little Cottonwood Canyon at Alta, Utah. Longtailed voles were implanted with radioactive tantalum and a standard geiger counter with 12 switchable gamma probes was utilized to determine movement patterns and residence time in nests. Trap and trackboards were also utilized to obtain more movement information and to compare these methods. Activity patterns near and at the nest were determined in the fall, midwinter, and early spring. Vertical trap and trap board enclosures were installed in fall to facilitate trapchecks in winter. Home ranges were superimposed on habitat maps and correlations of home range and vegetation type were made. Activity patterns changed during the years as a function of photoperiod and breeding condition. Lactating females spent more time in the nest and nest area and their activity patterns switched from principally diurnal to 4 hour bouts with an ultradian organization. When snow cover was established activity patterns were no longer circadian but were ultradian bouts equally spaced throughout the 24 hour day during early snow cover, but in late snow cover tended to become more diurnal.

Bio. 13
EVALUATION OF SEAFOOD PROCESSING WASTES AS A PROTEIN SOURCE IN CATFISH DIETS. Jan C. Dean*, Louis A. Helfrich, and Larry A. Nielsen. Dept. of Fisheries & Wildlife Sciences, VPI & SU, Blacksburg, VA 24061.

A growth trial involving caged channel catfish (Ictalurus punctatus) was used to evaluate the feasibility of seafood processing by-products as replacements for fish meal in fish feeds. A commercial dry feed (Purina Caged Catfish Chow) containing fish meal was compared with two experimental diets containing either herring (Clupea harengus) cannery residue or blue crab (Callinectes sapidus) meal at 15 percent of the diet. Two hundred and fifty catfish (20 g average) were stocked into each of nine cages (1 m^3) and were fed one of the three diets at 3% of live body weight per day for 136 d. The control, finfish, and crab diets contained 40, 34 and 31% crude protein, respectively; corrected for chitin content. Net production and growth rates of fish fed the control and finfish diets were statistically similar but were significantly greater than fish fed the crab diet ($P<0.005$). Body weight of catfish fed the control, finfish and crab diets increased an average of 7.6, 7.2 and 5.2 fold, respectively, between May and October. Feed conversion efficiency and survival were similar for all diets.

Bio. 14
GROWTH AND HEPATIC ENZYME ACTIVITY IN WILD RAINBOW TROUT (Salmo gairdneri Richardson) FROM VIRGINIA. Jan C. Dean* and Gino L. Lucchetti.* Department of Fisheries & Wildlife Sciences, Virginia Polytechnic Institute and State University, Blacksburg, Virginia 24061.

The relationship between growth and the activity of selected liver enzymes was assessed in one-year-old rainbow trout from Virginia streams. Trout were electroshocked from three second- and third-order streams in southwestern Virginia: Lewis Fork (LF), the South Fork of the Holston River (SFH), and Spring Branch (SB). Collections were made in July when water temperature was approximately 14°C. Fish were aged by scale analysis, weighed and measured. The activities of glutamate dehydrogenase (GDH), aspartate aminotransferase (GOT) and alanine aminotransferase (GPT) were quantified via kinetic spectrophotometric procedures at 30°C. Body weight (and instantaneous growth) differed significantly among streams and averaged 14.9 (4.99), 36.1 (5.87) and 55.5 g (6.29) for LF, SFH and SB, respectively. Tissue GDH (and GOT) activity also differed significantly among streams and averaged 48.7 (75.9), 41.5 (64.7) and 35.1 (55.2) units per g of liver for LF, SFH and SB, respectively. GDH and GOT activity were each negatively correlated with instantaneous growth. Condition factor and GPT activity did not differ among streams.

Bio. 15
DEVELOPMENT AND SEXUAL MATURATION IN PINE VOLES (MICROTUS PINETORUM). Terry L. Derting and Jack A. Cranford, Biology Dept., Virginia Polytechnic Institute, Blacksburg, Va. 24061.

Body and reproductive organ weights for pine voles maintained under either LD8:16 or LD16:8 at 5, 10, 15, 20, and 28 weeks of age were determined. Body weights of males and females raised on the short photoperiod were consistently greater by 2-4g than those for animals raised on the long photoperiod. Similar responses occurred with respect to seminal vesicle weights from males 15-28 weeks of age, with those from animals on LD8:16 being heavier than those from animals on LD16:8. The effect of photoperiod on testes was less apparent though the LD8:16 group killed at 20 weeks of age had heavier testes than those from LD16:8. Uterine weights of females maintained on the short photoperiod were consistently heavier than those maintained on the long photoperiod, with the greatest differences occurring at 5 and 20 weeks of age. There was little difference in the ovarian weights of females maintained under the two photoperiods. However, histological examination of the ovaries showed a greater proportion of tertiary follicles (>450 microns) in females on LD8:16 than those on LD16:8 at 5 weeks of age. By 20 weeks of age the pattern was reversed with more tertiary follicles occurring in females maintained on the long photoperiod.

Bio. 16
HEAVY METALS IN BENTHOS AND SEDIMENTS FROM THE CHESAPEAKE BAY REGION.
R. T. DiGiulio*and P. F. Scanlon, Dept. of Fisheries & Wildlife Sciences, VPI & SU, Blacksburg, VA 24061, J. van Montfrans*, VIMS, Gloucester Point, VA 23062, and G. M. Haramis*, USFWS, Laurel, MD 20841.

We measured cadmium, copper, lead, and zinc concentrations in aquatic macrophytes, clams, and sediments from 20 locations in the Chesapeake Bay region. Element concentrations were determined on a dry weight basis by flame atomic absorption spectrophotometry. Aquatic macrophytes examined include Ruppia maritima, Vallisneria americana, and Zostera marina. Clam species studied include Macoma balthica, Mya arenaria, and Rangia cuneata. In general, plants had higher concentrations of cadmium and lead while clam meats had higher levels of zinc; no clear difference was observed in copper concentrations. In sediments, significant positive correlations were found between organic matter and concentrations of copper, lead, and zinc. Significant positive correlations were observed between concentrations of copper, lead, and zinc in plants and the amounts of these metals per gram of organic matter in associated sediments. Similar correlation were observed between clam and sediments for copper and lead, but not zinc.

Bio. 17
A STUDY OF THE RECOGNITION AND UTILIZATION OF MYTILUS AS A FOOD SOURCE BY RATTUS NORVEGICUS.
R.B. Drinkwater*. Dept. Fisheries and Wildlife Science, Va. Polytechnic Inst. and State Univ., Blacksburg, VA 24061.

Feeding experiments were conducted on 3 wild rats trapped in an urban environment in Portsmouth, Virginia, remote from any source of mussels. The rats failed to open any mussels after a 24 to 48 hour deprivation period, but appeared to recognize mussels as a potential food. Field observations gave no evidence of mussel consumption by rats.

Bio. 18
PRELIMINARY ANALYSIS OF A FIELD TECHNIQUE FOR AGE DETERMINATION OF BOBCATS.
R.B. Drinkwater* and B.S. McGinnes. Dept. Fisheries and Wildlife Science, Va. Polytechnic Inst. and State Univ., Blacksburg, VA 24061.

Measurements were made of the ridges on the upper canine teeth of 46 bobcat skulls. Several indices were constructed using these measurements, the intercanine distance, and the zygomatic width, and tested against age by correlation analysis. Index I was strongly correlated with age in males. Correlations for females were weak and overlaps of several age classes were noted. Males could be grouped in age classes 0, 1, and 2-or-over.

Bio. 19
COLONY FOUNDATION IN THE RED CARPENTER ANT, CAMPONOTUS FERRUGINEUS.
John Dukes, III. Department of Entomology. Virginia Polytechnic Inst. and State Univ. Blacksburg, VA 24061

The period of reproductive activity and colony foundation is crucial in the life cycle of ants. Colony foundation in Camponotus ferrugineus (Hymenoptera: Formicidae) was studied. A newly mated queen was allowed to rear her first brood to maturity. Fifty-five days were required for the maturation of the first adult worker. Eighteen workers were reared in the first brood and polymorphism can occur in the first brood of callows.

Bio. 20
THE LIFE CYCLE OF THE CAT LIVER FLUKE PLATYNOSOMUM FASTOSUM. Ralph P. Eckerlin Div. of Natural Sciences, Northern Va. Comnty. Col., Annandale, Va. 22003

The three host life cycle of the cat liver fluke Platynosomum fastosum, a member of the trematode family Dicrocoeliidae, was completed in the laboratory. The terrestrial snail Subulina octona was confirmed to be the molluscan intermediate host in Florida as it is elsewhere. The terrestrial isopod Venezillo evergladensis is the obligate arthropod intermediate host. Isopods become infected by ingesting daughter sporocysts containing the brevicercous cercariae. Isopods harbor metacercarial stages which are infective to vertebrates. Domestic cats, raccoons, and opossums were found naturally infected with adult flukes. Cats and laboratory mice were experimentally infected by feeding them metacercariae from isopods. The metacercaria is also infective to the amphibian Bufo terrestris and the reptiles Anolis carolinensis, A. sagrei, and Sceloporus woodi which harbor unencysted metacercariae in the gall bladder. Natural infections were found in A. carolinensis, A. equistris, A. sagrei, and Eumeces inexpectatus. These transport hosts play an important role in the spread of infections but are not obligate hosts in the life cycle.

Bio. 21
ONTOGENETIC INCREASE IN SONIC MOTOR NEURONS IN THE OYSTER TOADFISH. D. Economos* and M. L. Fine*. Dept. of Biology, Va. Commonwealth Univ., Richmond, Va. 23284 (sponsored by C. M. Conway).

The sonic motor nucleus (SMN) of the oyster toadfish, Opsanus tau, contains motorneurons which innervate sound-producing swimbladder muscles. Males and females produce an agonistic grunt call, but only male toadfish produce the courtship boatwhistle. In an attempt to look for morphological correlates of sexual dimorphism in sound production, we measured nucleus length and counted neurons in the SMN from a series of male and female toadfish ranging from 1 to 11 years of age. Neuron number increases with fish size for about 8 years and then levels off. SMN length increases as a linear function of fish length. There is no evidence of sexual differences in either measurement, and accordingly they cannot be used to explain sexual differences in toadfish sound production. A long-term increase in neuron number is unlike the condition in mammals in which the number of neurons is fixed prior to birth. Supported by NSF URP.

Bio. 22
STABLE ISOTOPES AS TRACERS OF LEAD TRANSFER THROUGH MAJOR SOIL COMPONENTS. Elias, Robert W. Dept. of Biology, Va. Polytech. Inst. and State Univ. Blacksburg, Va. 24061.

Because the isotopic composition of lead ores differs from the more radiogenic composition of lead in average crustal rocks, industrial lead can be distinguished from natural lead. Industrial lead enters the ecosystem from the atmosphere and can be identified on vegetation surfaces, in litter, and in the organic fraction of soil. Natural lead enters from rock weathering and can be identified in the inorganic soil fraction. Soil moisture is a mixture of the two lead sources.

Increased mining of ore bodies in the Missouri New Lead Belt has caused a shift in the isotopic composition of atmospheric lead, providing a clue to the origin, approximate time of entry, and rate of mixing of lead among the ecosystem components. The 150 year history of this isotopic shift was determined from pond sediments in the High Sierra. Eight years of direct atmospheric deposition were measured on natural and artificial surfaces. A proportionately larger fraction of the soil lead available to plants is of anthropogenic origin.

Bio. 23
THE SOUTHERN BOG LEMMING, SYNAPTOMYS COOPERI, IN THE DISMAL SWAMP.
Roger K. Everton and Robert K. Rose, Department of Biological Sciences, Old Dominion University, Norfolk, Virginia 23508

The Dismal Swamp bog lemming, Synaptomys cooperi helaletes, is one of several subspecies of small mammals unique to the Great Dismal Swamp. The ecology of this subspecies of Synaptomys was virtually unknown, primarily because no specimens had been collected during this century prior to its rediscovery in 1980. During 15 months of study, 25 grids of pitfall traps have been established in an effort to determine the distribution, habitats, and present status of S. c. helaletes, as well as to obtain information on other species of small mammals in this unique area. Although S. c. helaletes was considered to be threatened, endangered, or even extinct by several investigators, it was the most abundant species caught and was present on half of the grids. Synaptomys was well represented outside the Dismal Swamp, especially on the western edge, and has been taken in a variety of habitats, ranging from wet boggy openings to dry young loblolly pine stands.

Bio. 24
AN ANALYSIS OF THE MUSCLE ISOZYMES PRESENT IN POPULATIONS OF THE DARTERS ETHEOSTOMA NIGRUM AND ETHEOSTOMA OLMSTEDI IN THE JAMES RIVER DRAINAGE (PISCES: PERCIDAE).
R. K. Falls* and W. S. Woolcott. Dept. of Biology, Univ. of Richmond, VA., 23173

A previously undertaken analysis of meristic characters of James River drainage populations of the closely related darter species Etheostoma nigrum Rafinesque and E. olmstedi Storer indicated that hybrid populations of the two occur in the Appomattox River drainage, a James River tributary. Samples have been taken from areas where specimens used in the original analysis were obtained. Homogenates of muscle tissue from the darters are being subjected to starch gel electrophoresis to genetically test the validity of the conclusion that hybrids exist. Enzyme systems looked at thus far include various dehydrogenases. Also in use is a modification of a general protein stain that was used to genetically confirm the existence of a morphologically described hybrid between the same parent species in the Ottowa, Canada area. At this time preliminary findings of the James River species study are inconclusive.
(Supported in part by a Univ. of Richmond Faculty Research Grant)

Bio. 25
AMMONIOGENESIS IN GILL MITOCHONDRIA FROM THE BLUE CRAB, CALLINECTES SAPIDUS.
Robert D. Fanelli* and David W. Towle*. Dept. of Biology, Univ. of Richmond, Richmond, VA 23173. (Sponsored by W.R. West, Jr.)

The blue crab, Callinectes sapidus, is a euryhaline invertebrate inhabiting aquatic areas with continually varying salinity levels. During conditions of decreasing salinity, Callinectes exhibits increased blood ammonia concentrations and increased ammonia excretion proposed to be the result of ammoniogenesis in gill mitochondria. Isolation of the mitochondrial fraction, by differential centrifugation, was followed by incubation with amino acids from the four major categories. Mitochondria were also incubated with ADP, rotenone, and FCCP in the presence of the two ammoniogenic substrates, serine and glutamic acid. The results indicate that gill mitochondria from Callinectes sapidus are indeed ammoniogenic, particularly with glutamic acid as a substrate. Additionally, there appears to be a relationship between ammoniogenesis and ATP production.
(Supported by Univ. of Richmond Undergraduate Res. Grant and John. N. Dickinson Res. Award.)

Bio. 26
HARBORAGE LIMITATION AS A COMPONENT OF A GERMAN COCKROACH (BLATELLA GERMANICA (L.)) PEST MANAGEMENT PROGRAM. B.R.Farmer*, W.H.Robinson. Dept. of Entomology, Va. Polytechnic Inst., Blacksburg, Va. 24061.

The possible use of harborage limitation as an enhancement of a German cockroach insecticide treatment was investigated. Apartment units with high numbers of German cockroaches were chosen from units administered to by the Roanoke Redevelopment and Housing Authority located in Roanoke, Va.. Exsisting harborage and possible structural harborage in kitchen and bathroom areas were located and sealed with caulking materials. Units were subsequently sprayed with a standard German cockroach insecticide and trap counts using fruit baited mason jar traps were taken. Prespray, 1, 2, 6 and 20 week postspray trap counts were taken and percent control determined. There were no signifigant differences between the 3 treatment units and the control group. Harborage limitation does not appear to be a useful technique for inclusion in a German cockroach pest management program.

Bio. 27
NEW GENUS AND SPECIES OF DIPLURAN (DIPLURA: CAMPODEIDAE) FROM A NEVADA CAVE. Lynn M. Ferguson. Dept. of Natural Sciences, Longwood College, Farmville, VA 23901

A new genus and species of campodeid dipluran has been identified from Whipple Cave, Lincoln County, Nevada. The new taxon is distinguished by the presence of large pretarsal claws with latero-tergal crests, rounded, setiform pretarsal appendices which are pubescent on their proximal half, and four pairs of macrochaetae on the pronotum. The form of the pretarsal claws and appendices are most like those of Hystrichocampa pelletieri Condé, known only from caves of France and Switzerland. This similarity in morphology is considered to be an example of parallel evolution between two cave-inhabiting campodeids.

Bio. 28
ISOLATION OF APICAL MEMBRANE FROM GILL ION-TRANSPORTING CELLS OF THE BLUE CRAB, CALLINECTES SAPIDUS. Cheryl A. Fletcher* and David W. Towle*. Dept. of Biology, Univ. of Richmond, Richmond, VA 23173. (Sponsored by W.R. West, Jr.)

Apical and basolateral membranes are unique regions of the epithelial cell plasma membrane which differ ultrastructurally, biochemically, and functionally. The gill tissue of the euryhaline blue crab, Callinectes sapidus, proved an efficient source of both plasma membrane fractions - apical and basolateral - which play important roles in a complex adaptation mechanism for ionic regulation. Apical membranes were isolated by differential and sucrose density centrifugation. Alkaline phosphatase and diazotised ^{125}I-iodosulfanilic acid were used as markers for the apical membrane. $Na^{+}+K^{+}$-ATPase and cytochrome oxidase served as enzymic markers for basolateral and mitochondrial membranes, respectively. Protein and chitin contents were also determined. The apical membranes were successfully separated from basolateral membranes and other organelles. Purification of these isolated membrane vesicles will allow characterization of the apical membrane with respect to transport function, hormone interactions, and other membrane phenomena. (Supported by Univ. of Richmond Undergraduate Res. Grant.)

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Bio. 29
ETHANOL-INDUCED HISTOLOGICAL CHANGES IN MOUSE CEREBELLUM. James A. French*, Arthur F. Conway, and Patricia L. Dementi, Dept. of Biology, Randolph-Macon College, Ashland, Va. 23005.

Male CD-1 mice were maintained with tap water, 4% ethanol in tap water, or 8% ethanol in tap water as their sole source of drinking water. After 3 or 6 weeks of treatment the mice were sacrificed with chloroform vapor and perfused with Karnovsky's fixative. The brains were removed by dissection, dehydrated in acetone series, and embedded in paraffin. Ten μ sections were prepared and stained with Azure A-Eosin B. Gross inspection of the brains at dissection revealed a discoloration of the cerebellar cortex and an abundance of erythrocyte-filled meningial vessels in mice treated with 4% ethanol. Microscopic examination of cerebellar tissues from all ethanol-treated groups showed either all or none of the molecular layer capillaries and the meningial vessels in a brain region filled with erythrocytes. In control animals approximately 50% of these vessels were filled with erythrocytes. The number of Purkinge neurons per microscope field was significantly reduced in all ethanol-treated groups as compared to controls. A significantly increased (compared to controls) number of the Purkinge neurons in all ethanol-treated groups were not oriented perpendicular to the molecular layer of the cerebellum.

Bio. 30
COMPARISON OF THE OSTEOLOGY OF THE DARTER PERCINA ROANOKA WITH SPECIES OF THE SUBGENERA ALVORDIUS AND ERICOSMA (PISCES: PERCIDAE). Ann S. Fulcher* and W. S. Woolcott. Dept. of Biology, Univ. of Richmond, VA., 23173

An osteological comparison was made to determine the relation of Percina roanoka to P. crassa (Ericosma) and to P. peltata (Alvordius). An enzyme method was used to clear and stain the specimens. Preliminary findings indicate that there are comparatively few osteological differences among the species, and those present are probably environmentally induced rather than phylogenetically related. (Supported in part by a University of Richmond Undergraduate Grant)

Bio. 31
THE DEVELOPMENT OF RANDOLPH-MACON WOMAN'S COLLEGE NATURE PRESERVES FOR UNDERGRADUATE STUDY. Virginia S. Godwin, Dept. of Biology, Randolph-Macon Woman's College, Lynchburg, Virginia 24503.

The development of three Randolph-Macon Woman's College nature preserves creates a new dimension in undergraduate field studies. The three tracts of land have been organized by the installation of research transects and grids for botanical and zoological sampling. The education potential resulting from the studies in these areas is excellent. They are presently being used as research areas for students interested in designing and executing independent study projects, as classroom teaching facilities for the comparison of diverse environmental conditions and habitats, and for ecological and taxonomic studies of various plants and animals. In addition to providing unique learning facilities, the nature preserves elevate the college community's appreciation and concern for nature. Organization, maintenance and use of these areas will be discussed. Suggestions for student and curricular usage will be made.

Bio. 32

LIFE HISTORY STUDIES OF THE BUMBLE BEE, BOMBUS FERVIDUS. Janet W. Goldblatt.* Department of Entomology, VPI&SU, Blacksburg, VA 24061.

Three captive colonies of Bombus fervidus which foraged freely were observed during the summer of 1981. At least every second day, newly emerged adults were individually marked with numbered tags, and a census of the adult bees in the colony was taken. Maps of the brood combs of the colonies were updated at every observation to record the progress of brood development.

Peak population and degree of colony success varied widely. The most successful colony (peak population 140 bees) produced 124 males and 4 queens. The second colony (peak population 52 bees) produced 30 males, but no queens were reared. The weakest colony never contained more than 7 workers, and produced no reproductives. The beginning of colony population decline coincides with the date of emergence of the first males.

Changes in developmental rates of workers and males over the course of the season were studied. Contrary to expectation, workers spend increased time in development as the season progresses. Males show the same trend. Workers take significantly less time to complete development than do males ($p<.05$).

Workers in each colony were divided into several cohort groups according to date of emergence. In every colony, longevity in adult bees varied among cohorts. Bees in the last cohort (early fall) have the shortest lifespans.

Bio. 33

THE EFFECT OF ALDOSTERONE AND CORTICOSTERONE ON A-6 TOAD KIDNEY CELL PROLIFERATION, V. A. Hampshire, R. T. Friedman, and C. W. Watlington. Dept. of Biological Sciences, Mary Washington College, Fredericksburg, Va. 22401, Dept. of Medicine, VCU, Medical College of Virginia, Richmond, Va. 23298

Aldosterone and corticosterone supplementation of media in A-6 Toad kidney cell cultures results in subsequent hyperplasia. Evaluation of cell proliferation was carried out using the hemocytometer method and alternately by ^{3}H Thymidine incorporation. Protein was measured using the method of Lowery (1951) and alternately by ^{14}C L-amino acid uptake. The results suggest that the effect of aldosterone and corticosterone is an increased rate of proliferation during preconfluent stages of growth manifested as a decreased doubling time and increased protein synthesis. This is followed by a decrease in protein synthesis and increased doubling time as the cultures reach confluence. Additionally, it is hypothesized that liquid scintillation assays will show that aldosterone binding to A-6 cells is greater in preconfluent cultures than in confluent cultures.

Bio. 34

MOLTING IN PINE VOLES AS AFFECTED BY AGE, SEX, NUTRITION AND PHOTOPERIOD. J. J. Hasbrouck and R. L. Kirkpatrick. Dept. Fisheries and Wildlife Sciences, VPI & SU, Blacksburg, VA 24061.

Some field studies have used pelage as a criterion for aging pine voles, yet few studies have investigated how various factors affect molt and pelage. Pine voles are born naked but by 10 days of age the dorsal surface has a smooth brown pelage and the ventral pelage is light gray. At approximately 5 weeks of age pine voles begin molting to adult pelage. Molt begins at the forelegs and proceeds anterio-posteriorly along the sides and ventrally. The molt progresses dorsally up the sides and back, then towards the rump, and finally the head molts to adult pelage. Completion of molt is highly variable, occurring between 8-10 weeks of age. Neither photoperiod (15L:9D vs 9L:15D) nor diet (apple-chow vs chow only) affected age of molt to adult pelage, but males completed molt at an earlier age than females. Voles fed an apple and horse chow diet initiated and completed molt at a heavier body weight than those fed chow only.

Bio. 35

ANALYSIS OF SPATIAL DYNAMICS OF THE PINE VOLE (MICROTUS PINETORUM).
J. J. Hasbrouck and A. R. Tipton. Dept. Fisheries and Wildlife Sciences, VPI & SU, Blacksburg, VA 24061.

A field study was conducted in a maintained and an abandoned apple orchard in Botetourt Co., VA. A 1/3 hectare live-trap grid was established in each orchard and the grids were trapped twice a day for 3 consecutive days each month since December, 1979. Primarily pine voles were captured in the maintained orchard and both pine and meadow voles in the abandoned orchard. Within a trapping period a greater number of pine voles moved at least one trap unit (10 m) from site of initial capture in the winter of 1980 and 1982 in the maintained orchard and in the summer and fall of 1980 and 1981 in the abandoned orchard. In the maintained orchard over 40% of the pine voles moved between trapping periods from spring, 1981 to winter, 1982. Over 50% of the pine voles in the abandoned orchard moved between trapping periods in the summer of 1980 and from summer, 1981, to winter, 1982. Pine voles were more evenly distributed throughout the grid in the maintained orchard though high numbers of voles (7-11) were trapped beneath some trees in April, 1980. In the abandoned orchard pine voles were trapped only in certain portions of the grid.

Bio. 36

ASPECTS OF THE DISSEMINATION AND REGENERATION OF EASTERN RED CEDAR (JUNIPERUS VIRGINIANA L). A. M. A. Holthuijzen* and T. L. Sharik, Dept. Fish. and Wildl. Sci., VPI & SU, Blacksburg, VA 24061.

Red cedar rapidly invades pasture lands in Virginia, where it is a considerable pest. It was hypothesized that a nearly even-aged red cedar regeneration pattern may originate from a dormant seedbank or an annually generated seed rain from nearby sources. To test these alternative hypotheses, soil samples were collected in 11 red cedar stands between 4 and 60 years old and in 4 recently abandoned fields with increasing distance from 4 (semi-) isolated fruiting trees. Over a 2-year period germinants of red cedar were abundant in soil samples collected under the canopy of the 4 trees, but dropped to minimal levels in samples collected outside the canopy area. It was concluded that cedar seeds apparently do not accumulate in the soil. The seed rain, established from seed traps placed along radii about the 4 trees, tapered off dramatically outside the canopy. However, the annual seed rain was considered sufficient to cause the observed regeneration pattern.

Bio. 37

Sister Chromatid Exchange Patterns As Induced By Human Serum Fractions. Evelyn Jemison, Patricia Goad, and Lynette Robinson.* Cytogenetics Laboratory, Department of Life Sciences, Virginia State University, Petersburg, Virginia 23803.

Human serum fractions are chromatographically analyzed and are assessed as to effects on the sister chromatid exchange patterns of BrdU-labeled chromosomes. PHA-stimulated lymphocytes, cultured in tissue culture medium 199, containing varied kinds of serum fractions, were incubated at 37°C. Hemacytometer counts at 0, 24, 48, and 72 hours determined the proliferative responses in cell growth at 48 and 72 hours. At 52 hours, the cells are harvested and stained for chromosomal analysis. Preliminary studies showed morphological changes in the chromosomal analysis. Preliminary studies showed morphological changes in the chromosomes including variations is size, shape, and density. Sister chromatid exchange patterns are being analyzed.
(Supported by NIH/MBS Grant S06-RR-08090-09 and NIH/MRC Grant T32- GM07678

Bio. 38
ELECTROPHORETIC ANALYSIS OF HUMAN SERUM FRACTIONS AFTER CHROMATOGRAPHY. Evelyn Jemison, Dwayne M. Little* and Dierdra Terrell. Cytogenetics Laboratory, Department of Life Sciences, Virginia State University, Petersburg, Virginia 23803.

Electrophoretic patterns of human serum fractions were determined subsequent to ion-exchange chromatography. The components of the four bands were eluted separately from the DEAE cellulose column which was used as an ion-exchange resin. Each fraction upon electrophoresis was assayed for the following major components: serum-globulin, alpha^1-globulin, alpha^2-globulin, beta-globulin and gamma-globulin. Eluted fractions substituted for fetal calf serum produced variable changes in cell proliferation patterns from normal PHA stimulated cells. Further efforts are now in progress to electrophoretically determine the specific components of each fractions. (Supported by NIH-MBRS Grant No. S06-RR-08090-10).

Bio. 39
THE CHROMATOGRAPHIC ANALYSIS OF HUMAN SERUM FOR THE LEUKOCYTE TEST SYSTEM. Evelyn Jemison, Bernard Parker* and Dierdra Terrell. Cytogenetics Laboratory, Department of Life Sciences, Virginia State University, Petersburg, Virginia 23803.

The lymphocyte culture system is used to bioassay the effects of human serum on PHA-stimulated lymphocytes. Both complete human serum and serum with alpha-globulins removed are used as growth factor substitutes in place of fetal calf serum at varying percentages to supplement tissue culture medium 199. Protocols were projected from earlier bioassays designed to determine the effects of human plasma fractions as a growth factor for the lymphocyte tissue culture medium. Unassayed control serum was employed in this ion-exchange chromatography procedure, using DEAE cellulose as the ion-exchange resin. The results: four different bands were adsorbed. The fractions collected were: fraction 1-pink; fraction 2-orange; fraction 3-dull yellow; fraction 4-bright yellow. These fractions were electrophoretically analyzed and tested in lymphocyte test systems. (Supported by NIH-MBS Grant No. S06-RR-08090-10)

Bio. 40
RELATIONSHIP OF TAENIA TAENIAEFORMIS STROBILOCERCI AND BODY AND REPRODUCTIVE ORGAN WEIGHTS IN PINE VOLES. E. J. Jones*, J.J. Hasbrouck*, and F. A. Servello*. Dept. Fisheries & Wildlife Sci., Va. Polytechnic Inst. & State Univ., Blacksburg, VA 24061.

Pine voles (Microtus pinetorum) collected from an apple orchard in Boutetourt County were examined for the presence of Taenia taeniaeformis strobilocerci. Voles were collected from 2 areas of an orchard, one where the apple drops were removed (R) and the other where the apples were available (A). Of the 105 males collected 6.7% were infected with T. taeniaeformis. Paired adrenal weights, paired testes weights, and relative testes weights were significantly greater ($P<0.05$) in infected voles. Males from area A had greater ($P<0.05$) body, paired adrenal, and seminal vesicle weights, and sperm counts. Infected, nonpregnant females (N=7) had greater body weights ($P<0.001$) and uterine weights ($P<0.08$) than uninfected, nonpregnant females (N=100). No difference was observed in the adrenal and ovarian weights. No infected, nonpregnant females were collected from area R. Only 2 of 8 pregnant females harbored strobilocerci. Paired adrenal weights were greater ($P<0.04$) and body weights tended to be greater ($P<0.09$) in the infected, pregnant females. Infections ranged from 1 to 3 strobilocerci per infected vole.

Bio. 41
HISTOPATHOLOGY OF WHITE-FOOTED MICE INFECTED WITH FRANCISELLA TULARENSIS. T. J. Jones*, Dept. Fisheries & Wildlife Sci., H. P. Veit*, Col. of Veterinary Med., and B. S. McGinnes*, Va. Cooperative Wildlife Res. Unit, Va. Polytechnic Inst. & State Univ., Blacksburg, VA 24061.

The histopathologic changes in the kidney, liver, and spleen of white-footed mice (Peromyscus leucopus) infected with Francisella tularensis were observed. Adult male white-footed mice were infected intraperitoneally with 10^2 organisms of virulent F. tularensis strain Schu 4. Mice were killed at 1 h, 6 h, 18 h, 24 h, 48 h, 72 h, and 96 h postinfection (PI). Kidneys, liver, and spleen were excised, preserved in 10% neutral buffered formalin, and later processed and stained with hematoxylin and eosin for histologic examination. No changes were observed until 24 h PI when some lymphoid follicular hyperplasia was noted in the spleen. At 48 h PI definite follicular degeneration was evident in the spleen, and slight congestion of the glomerular tufts in the kidney. The liver exhibited multifocal hepatocellular necrosis, neutrophils, and edema. For mice sacrificed at 72 h and 96 h PI, the same degenerative conditions were evident as well as some hepatic and splenic congestion. The bacteria were cultured from tissues collected at 18 h PI and later.

Bio. 42
A MODIFICATION OF THE LESLIE MATRIX MODEL TO ACCOMMODATE HIGHER ORDER POPULATION STRUCTURES. K. C. Jordan and A. R. Tipton. Dept. Fisheries and Wildlife Sciences, VPI & SU, Blacksburg, VA 24061.

Most discrete-time population simulators involving structured populations utilize, in some form, the Leslie matrix model. In such models the population is structured by discrete 1-dimensional age classes, usually of interval length equal to the time step over which the model operates. For some populations, however, another criterion, such as size or developmental stage, may be more appropriate for structuring the population. And in some cases, 2 or more criteria may be necessary to adequately describe the population. In the 1-dimensional case, the model objective is to simulate transitions within the single criterion dimension, and if the criterion is age the transitions are always progressive, from lower to higher values of age. In the multi-dimensional case, transitions may occur within all criterion dimensions simultaneously or between any combination of them, and depending on the nature of the criteria, may proceed in more than 1 direction. A facile technique is suggested for transforming higher order population structures into vectors for multi-dimensional projection through discrete time.

Bio. 43
PHOTOSYNTHETIC LIGHT UTILIZATION BY ANTARCTIC PLANKTON. M. Kaspar, B. C. Parker, G. M. Simmons, Jr. and K. G. Seaburg. Dept. of Biology, Virginia Tech, Blacksburg, VA 24061

Photosynthetic quantum yield (Ø) was determined for the phytoplankton of four perennially ice-covered Antarctic lakes. The phytoplankton of these lakes are dominated by small Chrysophytes or Cryptophytes. Ø calculated from particulate incorporation ranges from 0 to .052. When corrected for extracellular release of organic matter by the phytoplankton, these values increased. In each lake Ø increased from low values at shallower depths immediately under the ice covers to maximal values at intermediate depths. In two lakes no detectable primary production occurred at greater depths. Estimates of Ø for these lakes compare with values reported for marine and freshwater plankton habitats elsewhere in the world. Although the phytoplankton are not more efficient at utilizing photosynthetically available radiation (PAR), the taxa present are adapted to utilizing a range of PAR considerably lower than phytoplankton in the photic zones of most other lakes.

Bio. 44
THE PATHOLOGICAL EFFECTS OF GOSSYPOL IN MICE. Stephen D. Keefe, R. James Swanson, William G. Garrison, Steven B. Ackerman, Chris Hall and J.W.E. Wortham, Jr. Dept. of Biol. Sci., Old Dominion Univ. Norfolk, Va. 23508.

Groups of C57 Black mice were injected subcutaneously with either 6.25, 12.5 or 25 mg/Kg body weight gossypol acetic acid in corn oil over a 13 day period. Mice were injected dorsally between the scapulae. Toxic reactions including lethargy, peripheral edema, unilateral or bilateral forelimb swelling and alopexia were exhibited be all treated mice. Several of the mice in the groups receiving higher doses died of undetermined causes. Surviving mice were sacrificed 7, 14 or 23 days after the last gossypol injection and various organ were excised, weighed and prepared for light and electron microscopy. Data is presented comparing organ weights, sperm counts and light and electron microscopic histopathology between treated mice and corn oil injected controls.

PROBE COLORIMETRY FOR QUANTITATION OF ENZYME-IMMUNOASSAYS. Eileen Kelly and Steven B. Ackerman. Dept. of Biol. Sci., Old Dominion Univ., Norfolk, Va.

The performance of a fiber optic probe colorimeter for quantitating enzymatic or colorimetric assays in 96-well microtiter plates was compared to a spectrophotometer and a commercially-available enzyme immunoassay reader. Alkaline phosphatase/p-nitrophenyl phosphate in 3M NaOH was used as chromophore source. Six types of plates were evaluated for use with the probe colorimeter and generated reproducibility values (100%-CV) ranging from 92.5-97.4% when one individual made 24 independent measurements on the same dilution of chromophore in each plate. Using the colorimeter eleven different individuals each performed 24 measurements on either a visually light or dark dilution of chromophore and reproducibility averaged 88.4% for the light and 96.1% for the dark dilution. When one individual measured the same chromophore sample 20 or 24 times in the colorimeter, a spectrophotometer or in an enzyme immunoassay reader reproducibility for each instrument was greater than 99%. For each instrument measurements of a dilution series of chromophore in a fixed volume indicated optical responses were linear in a range of 0.05-1.10 absorbance units.

Bio. 46
ELECTIVITY AND TROPHIC OVERLAP BETWEEN POSTLARVAL SMALLMOUTH AND SPOTTED BASS IN CLAYTOR LAKE, VIRGINIA. W.E. Kelso*, and J.J. Ney. Dept. of Fisheries and Wildlife Sciences, VPI & SU, Blacksburg, Va. 24061.

The magnitude of trophic competition among postlarval young-of-the-year fishes has not been defined. These interactions may be intense in mainstream reservoirs where littoral nursery areas are limited. Measures of niche overlap combined with data on food abundance can be used to indicate the probable significance of these competitive interactions.

Niche overlap between postlarval smallmouth and spotted bass was measured along three axes of the trophic niche: food type, food size, and feeding periodicity. Overlap between the two species was high as both preyed on copepods, Bosmina longirostris, and a variety of littoral chydorid cladocerans. Temporal partitioning seemed unlikely as stomach contents indicated feeding during most of the daylight hours. In Claytor Lake, smallmouth bass utilize most of the lake for reproduction and early growth, while spotted bass are restricted to a few small coves. Results indicate smallmouth bass may inhibit spotted bass growth during the critical postlarval period.

Bio. 47
IDENTIFICATION OF FISH HOST(S) FOR AN ENDANGERED SPECIES OF FRESHWATER MUSSEL (Fusconaia edgariana). H. E. Kitchel* and R. J. Neves.* Dept. of Fisheries & Wildlife Sciences, VPI & SU, Blacksburg, VA 24061.

Identification of fish host(s) species is essential to understanding the reproductive biology of endangered freshwater mussels. Determination of potential fish host(s) was investigated for the shiny pigtoe mussel (Fusconaia edgariana), one of 9 endangered mussel species in Virginia. Field collections of mussels and fish were made bimonthly from June to December 1981 at North Holston Ford, North Fork Holston River, near Saltville, Virginia. Quadrat surveys revealed a density of 10.6 mussels/m^2 for the 14 species of mussels at the site, and a shiny pigtoe density of 0.5/m^2. Stream drift was sampled weekly with 130 μ mesh nets to determine the glochidial release period. Peak glochidial densities occurred in July drift samples. Observations on gravid females at the site indicated a 3 week release period in July. In the lab, gravid females were induced to release glochidia from 25 June to 30 July under controlled conditions, and the glochidia were used in artificial infections of potential fish host(s). These induced infections were conducted from 30 June to 25 July on 11 of the 34 fish species present at the site, but none of these fish species served as host. Examination of naturally infected fish at the study site indicated that some cyprinids were apparently serving as the fish host(s) of the shiny pigtoe mussel. Determination of the requisite fish host(s) for Fusconaia edgariana and other aspects of its reproductive biology is fundamental to implementation of an endangered mussel recovery program.

Bio. 48
OVIPOSITOR MORPHOLOGY OF THREE LIRIOMYZA SPECIES (DIPTERA: AGROMYZIDAE). J.J. Knodel-Montz*, S.L. Poe, Dept. of Entomology, Va. Polytechnic Inst. and State Univ., Blacksburg, Va. 24061.

Scanning electron microscopy revealed structural differences in the ovipositor of three economically important species of Liriomyza (L. sativae, L. trifolii, L. huidobrensis). The ovipositor consists of abdominal segments VII-IX. Segment VII is cone shaped and modified into a closed ovipositor sheath. Numerous tactile setae and a spiracle were found on this segment. The dorsal and ventral surfaces of segment VIII are provided with anteriorly directed denticles arranged in the form of file-teeth, which may facilitate the operation of rasping the leaf tissue of the host plants. Liriomyza sativae has long angular denticles; L. trifolii broad triangular denticles; L. huidobrensis conical denticles on the eight segment. The lateral surfaces are pilose, and several long trichoid sensilla are located near the distal margin. The ninth segment is slender and entirely membranous. Two cerci extend distally from segment IX. Each cercus has a variable number of sensory sensilla of the basiconical type. Liriomyza sativae and L. trifolii have six basiconic pegs, while L. huidobrensis has four pegs. Structural differences in the ovipositor has potential for use in taxonomic identification.

Bio. 49
SEASONAL DISTRIBUTION OF MAYFLIES (EPHEMEROPTERA) IN TWO PIEDMONT RIVERS IN VIRGINIA. B. C. Kondratieff* and J. R. Voshell, Jr., Department of Entomology, Va. Polytech. Inst. and St. Univ., Blacksburg, Va. 24061.

The seasonal distribution of mayflies was studied in the North and South Anna Rivers. A study site was established on each river at the Fall Line. Nymphs were collected in riffles with a Portable Invertebrate Box Sampler (PIBS), D-frame dip net, and by hand. Imagoes and subimagoes were collected with black light traps and with lights at white cloth sheets. Fourteen species were encountered in sufficient numbers to determine their seasonal periodicity; twelve other species that occurred infrequently are listed. The fauna could be divided into three temporal components based on the time of their emergence: winter/early spring, spring, and summer/fall. In the South Anna River the majority of the mayflies were closely associated with Podostemum ceratophyllum (river weed). The thick mats of this macrophyte provided food and shelter for a mayfly community dominated by Ephemerellidae and Baetidae. In the North Anna River Podostemum was conspicuously absent, and the mayfly community was dominated by Heptageniidae and Baetidae.

Bio. 50
COMPARISON OF THYROID HORMONE CONCENTRATIONS IN BLOOD OF WHITE-TAILED DEER FROM VIRGINIA AND TEXAS. V. E. Kopf*, D. L. Drawe*, P. F. Scanlon, and F. C. Gwazdauskas, Depts. Fisheries and Wildlife Sciences and Dairy Science, VPI & SU, Blacksburg, VA 24061 and Rob and Bessie Welder Wildlife Foundation, Sinton, TX 78387.

Possible differences among white-tailed deer (Odocoileus virginianus) from different areas in circulating concentrations of thyroid hormones (throxine; T_4 and triiodothyronine; T_3) were investigated in free-ranging deer collected from Virginia and south Texas in April 1981. Blood serum from 12 deer from the Radford Army Ammunitions Plant (RAAP), Radford, VA and from 30 deer from the Rob and Bessie Welder Wildlife Foundation, Sinton, TX was analyzed using radioimmunoassay procedures. Concentrations of T_3 were significantly ($P<.02$) higher in VA deer ($\bar{X}$ = 1.36 ± 0.13 S.E., µg/ml) than in TX deer ($\bar{X}$ = 0.96 ± 0.06 S.E., µg/ml). Values of T_4 were not significantly different (VA deer mean = 132.88 ± 9.18 S.E., µg/ml vs 118.42 ± 5.85 S.E., µg/ml, for TX deer). Circulating concentrations of T_3 indicate differences among deer from the two areas which could be associated with numerous factors associated with quantity and quality of food intake which are currently being investigated.

Bio. 51
THYROID HORMONE CONCENTRATIONS IN BLOOD OF PREGNANT WHITE-TAILED DEER. V. E. Kopf*, P. F. Scanlon, R. L. Kirkpatrick, and F. C. Gwazdauskas. Depts. of Fisheries and Wildlife Sciences and Dairy Science, VPI & SU, Blacksburg, VA 24061.

This study investigated the effects of pregnancy and number of fetuses (1 or 2) on the circulating concentration of triiodothyronine (T_3) in white-tailed deer (Odocoileus virginianus). Twenty yearling does were held on 2 dietary planes (high energy, HE, of ad libitum intake of 3800 kcal DE/gm and low energy, LE, which was 50% of ad libitum intake). Does were exposed to males from 5 November to 3 January. Blood samples were taken from does by manual restraint at 28 day intervals. Five deer were non-pregnant while 9 deer were pregnant with 1 fetus and 6 deer were pregnant with 2 fetuses. Circulating concentrations of T_3 were not significantly affected by sampling date, month of pregnancy, or the number of fetuses carried. Interactions between the main effects were also non-significant. The number of fetuses and stage of gestation apparently do not directly influence the circulating concentrations of T_3.

Bio. 52
INTRODUCTION FROM EUROPE OF A BEETLE, ANTHRIBUS NEBULOSUS, A NEW BIOLOGICAL CONTROL AGENT OF COCCOIDEA IN VIRGINIA. M. Kosztarab, Dept. of Entomology, VPI & SU, Blacksburg, VA 24061, and F. Kozár*, Res. Inst. for Plant Prot., Pf. 102, Budapest 114, Hungary, H-1525.

Anthribus nebulosus Forst. (Coleoptera: Anthribidae), as a predator of soft scales, was first brought to Virginia in 1975, and after three years of rearing and studies in the beneficial insect quarantine laboratory at VPI & SU, was first field-released during 1978. This insect became established at a low population level in the Blacksburg area on the spruce-infesting soft scale, Physokermes hemicryphus (Dalman) by 1980. A moderate control level was reached by 1981. More beetles were field-released at Virginia Beach during 1981 for the control of the Oak Lecanium, Parthenolecanium quercifex (Fitch), on pin oaks in the area. The released populations are being monitored at present. New introductions, laboratory rearings, and field releases are planned.

The beetle has one generation per year. Adults overwinter; lay their eggs under the soft scale females in the spring; each larva occupies the brood chamber and consumes the scale eggs; pupates there and the adult emerges through a hole chewed through the female's exoskeleton during early summer. Their life cycle closely parallels the phenology of the host scale.

Bio. 53

OBSERVATIONS ON THE BIOLOGY AND BEHAVIOR OF ANTHRIBUS NEBULOSUS FORST. (COLEOPTERA:ANTHRIBIDAE), AN INTRODUCED PREDATOR OF SCALE INSECTS IN VIRGINIA. M. Kosztarab and Mary Rhoades*, Dept. of Entomology, Va. Polytechnic Institute & State Univ., Blacksburg, Virginia 24061.

Anthribus nebulosus adult beetles, whose larvae are predators of scale insect eggs in Europe, were observed from late July to November in the laboratory to find out their eating habits, shelter preferences, ways of interacting with each other and their environment, and other general patterns of behavior. Natural honeydew from 3 species of scale insects, artificial honeydew, sugar-water solution, water and fungi were consumed. Live scale insects (representing 4 families) in all stages from egg to adult were never eaten by the beetles, but old dry female scale insect bodies were chewed on to a limited extent. Beetles showed a wide range of responses to shelters, from some never entering a shelter to one entering and staying there for 2½ months. One fourth of the beetles sought permanent shelter. Old female scale insect bodies were preferred as permanent shelters to black paper ones, and in one case two beetles shared the same scale shelter. Physical interaction between beetles was practically nonexistent. Beetles spent more time on twigs of spruce, oak and tulip tree than in the open. The average weight of a beetle in mid-November was 3.6 mg (range 1.5-7.4 mg). Length averaged 4.0 mm (range 3.0-4.8), width 1.7 mm (range 1.2-2.1).

Bio. 54

HISTOLOGICAL ANALYSIS OF REPRODUCTIVE TRACTS OF IMMUNE-STIMULATED FEMALE MICE. Diana I. LaPasha*, Arthur F. Conway, Dept. of Biology, Randolph-Macon College, Ashland, Va. 23005, Karyn Lacey*, and Carolyn M. Conway, Dept. of Biology, Va. Commonwealth Univ., Richmond, Va. 23284.

Immune stimulation of female CD-1 mice was achieved by subcutaneous injections of thyroid homogenate- or saline-Freund's adjuvant emulsions. Immunized and control females were sacrificed at 1 week intervals and perfused with 4% paraformaldehyde in 0.01 M phosphate buffer, pH 7.4. Reproductive tract tissues were removed, dehydrated in an acetone series and embedded in Quetol. Four micron sections were stained with Azure A-Eosin B and evaluated microscopically. Immune system cells were counted in at least 5 fields per slide. Integrity of epithelial tissues was evaluated on a scale of 0 (normal) to 3 (disintegrating). The numbers of lymphocytes in the ovarian stroma, plasma cells in the ovarian stroma and the wall of the oviduct, and mast cells in the wall of the oviduct and uterus were significantly (ANOVA, $p \leq 0.05$) increased in immune stimulated mice. The epithelial integrity of the oviduct and Graafian follicles was significantly altered in immune stimulated mice. These changes are consistent with increased humoral immune system activity in the reproductive tracts of immune stimulated mice. (Supported in part by an NSF-RAMHSS Program at Va. Commonwealth Univ.)

Bio. 55

VARIATION IN MUSCLE DIAMETER WITH DURATION OF EXERCISE. A. Stuart Luther*, and Patricia L. Dementi, Dept. of Biology, Randolph-Macon College, Ashland, Va. 23005.

The effect of exercise on skeletal muscle fiber size in mice was studied by varying the duration of exercise and examining the fixed and sectioned gastrocnemius muscles for evidence of hypertrophy or hypotrophy. Eleven male albino mice paired with controls according to weight were exercised five, ten, and fifteen minutes per day. All mice were sacrificed weekly over a period of four weeks. Tissues were fixed by vascular perfusion, and the gastrocnemius muscles excised, embedded in plastic, sectioned at 4 μ and stained with Azure A-Eosin B. Fifty randomly chosen fibers from each mouse were measured and averaged to compute further statistics. Fifteen minutes of exercise per day was found to cause significant fiber hypertrophy, whereas five and ten minutes of exercise per day caused hypotrophy. Statistical analysis indicated that weight was a factor in muscle fiber diameter, but not nearly as significant as experimental treatment.

Bio. 56

THE ROLE OF ACROSIN AND SAMPLE FREEZING IN SPERM PENETRATION THROUGH HUMAN CERVICAL MUCUS. M. Condon Mahony,* R. J. Swanson & J. W. E. Wortham, Jr. Dept. of Biological Sciences, Old Dominion Univ., Norfolk, VA 23508-8503

Human cervical mucus from two groups of cycling females was tested for penetrability against human semen from normal proven-fertile males. No form of contraception had been used by either group of females for at least two years prior to this study, and all cervical mucus was collected at mid-cycle as determined by temperature charting, quality of cervical mucus, and timing of menstrual period. Females were divided into reproductively normal and infertile groups. The normal group consisting of parous and nonparous individuals received no drugs or hormones during the study. The infertile group received a regimen of Pergonal and hCG prior to cervical mucus collection. Samples were either examined immediately or frozen before testing. In the acrosin study, two inhibitors were added to the semen before inserting the flat capillary tube containing cervical mucus into it. Preliminary results indicated that the combination of hormone treatment and freezing used in the infertile group had no effect on sperm penetration. The addition of acrosin inhibitors to the semen had no significant effect on the ability of sperm to penetrate cervical mucus.

Bio. 57

TEMPORAL PATTERNS OF BRAIN ACETYLCHOLINESTERASE INHIBITION IN TWO SPECIES OF WILD MAMMALS EXPOSED TO ORGANOPHOSPHATE PESTICIDES. W. Edward Montz, Jr.* and Roy L. Kirkpatrick, Dept. of Fisheries and Wildlife, Va. Polytechnic Inst. and State Univ., Blacksburg, VA 24061.

Three experiments were initiated to determine the temporal pattern of inhibition and recovery of brain acetylcholinesterase (AChE) activity following treatment with an organophosphate pesticide. In a preliminary experiment, an oral dose-inhibition curve was derived for 25 male white-footed mice (*Peromyscus leucopus*) treated with diazinon. In a second experiment, 90 female *P. leucopus* were given either 18.8 mg diazinon/kg body wt. or corn oil (control). This dose was chosen to cause approximately 60% inhibition of AChE activity in treated animals based on the results of the dose-inhibition experiment. Groups of 3 treated and 3 control mice were then sacrificed at 2, 4, 6, 8, 12, 16, 20, 24, 32, 40, 48 h, and 5, 8, 12, and 16 days. Maximal AChE inhibition (53%) occurred at 6 h and treated groups had significant inhibition at 6, 12, 18, 20, and 40 h ($P<0.05$, Duncan's Multiple Range Test). In a third experiment, 16 gray squirrels (*Sciurus carolinensis*) were randomly assigned to a treatment (0.35 mg parathion/kg body wt.) or control group (0.35 mg corn oil/kg). One treated and one control animal were sacrificed at 6, 12, 18, 24, and 48 h and 4, 8, and 16 days. Inhibition was greatest at 18 h (77%).

Bio. 58

PATTERNS OF BIOACCUMULATION OF HEAVY METALS IN STREAM FISHES. J. J. Ney, M. G. Martin,* and J. M. Mudre.* Dept. of Fisheries and Wildlife Sciences, VPI & SU, Blacksburg, VA 24061.

Concentrations of lead, zinc, nickel and cadmium were determined in the fishes of a roadside stream. Consistent differences were found in whole body metals concentrations among six lotic fish species. Trophic biomagnification, habitat selection and differential tissue composition/metals affinity were analyzed as sources of interspecific variation. Degree of association with the sediment (habitat selection) provided the most tenable explanation for interspecific variation.

Within species, whole body metals concentrations declined with duration of exposure (age). However, lead in bone and cadmium in kidney showed progressive increases. Analysis of tissues with storage affinities for particular metals may provide a means for rapid assessment of chronic metals contamination.

Bio. 59
THE UPTAKE OF LEAD IN NUTRIENT MEDIA BY MYCORRHIZAL FUNGI.
Owen, Mark H. and Robert W. Elias. Dept. of Biology Va. Polytechnic Inst. and State Univ., Blacksburg, VA 24061.

Ectomycorrhizal fungi concentrate lead within their hyphae when grown in media containing varying amounts of lead. Pisolithus tinctorius Pers. was cultured in liquid Hagem's media in which lead nitrate was added, producing lead concentrations in the media of 1.5 to 170 ng/ml, similar to those found in natrual soil moisture. Lead concentrations of the media and the mycelia were determined over a 21 day period. In all cases, the mycelial lead concentrations increased while the lead concentrations of the media decreased.

Bio. 60
RELATIVE ABUNDANCE OF MAMMALS IN SEVEN HABITATS OF THE PIEDMONT OF NORTH CAROLINA AND VIRGINIA. John F. Pagels. Dept. of Biol., Virginia Commonwealth University, Richmond, Va. 23284

Mammals, exclusive of bats, were studied in birch/willow (BW), old field (OF), and pine (PF), mixed hardwood/pine (HP), upland hardwood (UH), mesic cove hardwood (CH) and bottomland hardwood (BH) forest habitats in lands surrounding the J.H. Kerr Dam and Reservoir. Small mammal captures represented 11 species and 14 species were recorded from signs and sightings. The white-footed mouse, Peromyscus leucopus, comprised 67% of all captures and much of the remainder was made up of the hispid cotton rat, Sigmodon hispidus, and the pine vole, Microtus pinetorum. The greatest number of species was recorded in BW and OF, but relative abundance and diversity, H^1, for small mammals captured were among the lowest in BW and highest in OF. Relative abundance was very low also in PF and BH. The habitat with the highest relative abundance, CH, had the lowest H^1; Peromyscus represented 130 of 143 captures. The influence of the patchiness of the habitats and/or disturbance in the study area is indicated in species composition, relative abundance and diversity of species within given habitats. Only six of the species recorded are in close association with a single habitat; three with OF and three in stream-pond situations at BW habitats.

Bio. 61
FLEAS FROM MAMMALS OF FAIRFAX COUNTY, VIRGINIA. H.F. Painter*, and R.P. Eckerlin. Div. of Natural Sciences, Northern Va. Cmnty. Col., Annandale, Va. 22003

To date no definitive study has been made of the fleas of Virginia. In Fairfax County alone, 7 species had been reported by 1940 and only 8 were listed in 1980. In this study, 207 mammals of 23 species were examined in all months of the year and 427 fleas were collected. The following nine species of flea were found: Pulicidae - Cediopsylla simplex, Ctenocephalides felis; Vermipsyllidae - Chaetopsylla lotoris; Hystrochopsyllidae - Ctenophthalmus pseudagyrtes, Epitedia wenmanni; Ceratophyllidae - Orchopeas howardii, Orchopeas leucopus; Leptopsyllidae - Odontopsyllus multispinosis, Peromyscopsylla hamifer. Ctenocephalides felis, one of our most common fleas, and Chaetopsylla lotoris, had not been reported previously from Fairfax County. The need for more collecting is manifest. In addition, the total of 17 known Virginia flea species in 1940 had only risen to 25 in 1980. This in spite of the fact that as many as 40 species may be present in the state due to the overlap of southern species in the southeastern part of the state and northern species in the west. We invite data on fleas collected anywhere in the state.

Bio. 62

GENETICS OF THE BLACK MUTATION OF DROSOPHILA MELANOGASTOR. C. M. POSEY*, and A. F. Sherald. Dept. of Biology. George Mason Univ., Fairfax, Va. 22030

Biochemically, black is known to be partially deficient in β-alanine. It is assumed that this results from a biosynthetic lesion since black is cured by an exogenous supply (Hodgetts and Choi, 1974, Nature 252:710; Jacobs, 1974, J. Insect. Physiol. 20:859), and since the suppressor of black mutation accumulates β-alanine (Sherald, 1981, Mol. Gen. Genet.).

To date, a defective enzyme in β-alanine synthesis has yet to be found, and a review of Drosophila gene-enzyme systems has ruled out many enzymes of the major pathway (Hankins and Sherald, 1981, Drosophila Inform. Serv. 56:58).

In an attempt to provide genetic evidence that black does affect a structural enzyme in β-alanine synthesis, we have examined trans-heterozygotes of various black alleles for intracistronic complementation, and we are screening for temperature sensitive black alleles (thus far, no temperature sensitive black alleles have been found among 6,678 progeny).

Intracistronic complementation was not observed in 105 pair combinations of EMS, γ and x-ray induced black alleles. This evidence suggests that any enzyme defined by black is not a homodimer since 66 instances of intracistronic complementation were found among 105 tests for acid phosphatase, a known homodimer (Bell, et al, 1973, Biochem. Genetics 10:39).

Bio. 63

THE SOUTHEASTERN SHREW, SOREX LONGIROSTRIS, IN THE DISMAL SWAMP.
Robert K. Rose, Department of Biological Sciences, Old Dominion University, Norfolk, Virginia 23508

At least four species of small mammals have distinctive forms in the Great Dismal Swamp of eastern Virginia-North Carolina. The two shrews, short-tailed (Blarina telmalestes) and southeastern (Sorex longirostris fisheri) shrews differ from their upland congeners by having significantly larger body size. In this regard, the Swamp acts as an island, where small mammals are often larger than mainland races or subspecies. During 18 months of study, 25 0.25 ha grids of pitfall traps were set in a range of habitats in and surrounding the Great Dismal Swamp National Wildlife Refuge. In the summer of 1981, the vegetation of 23 grids was measured to determine the relationship between vegetation structure and the presence or absence of southeastern shrews. Overall, southeastern shrews were one of two most frequently captured small mammals, and they occurred from grassy openings through closed forests.

Bio. 64

PHYSIOLOGICAL ADAPTATIONS IN ANTARCTIC ALGAE. K. G. Seaburg, B. C. Parker, G. M. Simmons, Jr. and M. Kaspar. Department of Biology, V.P.I. & S.U., Blacksburg, VA 24061

The perennially ice-covered, closed-basin lakes of southern Victoria Land, Antarctica, offer an unusual opportunity to study salinity-adaptations in algae. The lake waters vary from fresh to those with chloride concentrations >10x that of seawater. Thirty-eight isolates (17 taxa) of benthic and planktonic algae, including pennate diatoms, filamentous cyanophytes, flagellated green algae and one chrysophyte were assayed for growth capability at concentrations of chloride equivalent to 0, 0.2x, 0.6x, 1.0x, 1.5x, and 2.0x that of seawater. The isolates from the most saline waters were the most halotolerant and included two halophilic taxa, both pennate diatoms. The fresher waters yielded isolates which were either halotolerant or obligate freshwater forms. Results of the assays agreed strongly with the natural distributions of the algae in the lakes. Halotolerance, therefore, is an important factor regulating the distribution of planktonic and benthic algae in the lakes.

Bio. 65
DIGESTIBLE ENERGY INTAKE, BODY WEIGHT, AND BODY FAT CHANGES IN PINE VOLES FED DIETS OF DIFFERENT DIGESTIBILITIES. A. M. Shull,* F. A. Servello,* R. L. Kirkpatrick, and A. R. Tipton. Dept. Fisheries and Wildlife Sciences, VPI & SU, Blacksburg, VA 24061.

Twenty-six voles were randomly assigned to 6 diets of graded digestibilities. Voles were fed these diets for 3 weeks. Food consumption was measured over a 3 to 5-day period during each week. Percent digestible dry matter (DDM) and percent digestible energy (DE) of the diets were measured by a digestion trial over a 5-day period during the second week. Voles were weighed weekly. Body fat analysis was conducted on the carcasses. Percent DDM of the 6 diets used ranged from 42.7% to 80.0%. Percent DE ranged from 44.4% to 83.9%. Food consumption increased as DE of the diet decreased. However, DE intake ($kcal/BW^{.75}/day$) was not significantly different between diets. There also was no significant difference in body weight change or percent body fat due to diet. These results indicate that the DE of a vole's diet can go as low as 44.4%, and the vole will still be able to meet its maintenance requirements for at least a 3 week period.

Bio. 66
COMMUNITY STRUCTURE IN SMALL MAMMALS OF THE DISMAL SWAMP.
Jean F. Stankavich and Robert K. Rose, Department of Biological Sciences Old Dominion University, Norfolk, Virginia 23508

Small mammals were live-trapped on two study grids in the northwest corner of the Great Dismal Swamp National Wildlife Refuge. The study area lies in a 40 m wide clearing under a 110 kv electric powerline. The community was monitored at 2-week intervals from December 1980 to January 1982. In all, 10 species were captured. Grid 1 was dominated by the harvest mouse (Reithrodontomys humulis) and the golden mouse (Ochrotomys nuttalli). Both were also numerically dominant on Grid 2, but the meadow voles (Microtus pennsylvanicus) also was frequently captured there. Populations from both grids were examined for breeding activity, mortality, growth and home range. Vegetative sampling revealed Grid 1 to be dominated by cane (Arundinaria gigantea) greenbriers (Smilax rotundifolia), sweet gum seedlings and saplings (Liquidambar styraciflua), and pine seedlings (Pinus taeda). Grid 2 was dominated by Juncus spp., sedges, grasses (Panicum spp.), and goldenrods (Solidago spp.)

Bio. 67
STUDES OF THE DISTRIBUTION OF FIDDLER CRABS (UCA) IN A BAHAMIAN MANGROVE TIDAL FLAT. Sherry Sterling*, William Sproat* and Luther Brown. Dept. of Biology, George Mason Univ., Fairfax, Va. 22030

Three species of fiddler crabs inhabit a tidal mangrove swamp on the east coast of Andros Island, Bahamas. The most abundant species are Uca pugilator and U. pugnax. U. Minax are more rarely encountered. The spatial arrangement of these crabs was investigated by establishing two parallel transects, each 1m wide and 32m long. Transects included diverse substrate types and tidal depths. All burrows within each transect were mapped and excavated. Captured crabs were sexed, identified to species, and measured (carapace width, chelae length). The effects of soil and water depths on burrow placement will be examined. Sex and size specific dispersion patterns will also be presented.

Bio. 68

COMPOSITION AND ECOLOGY OF THE BOTTOMFISH FAUNA OF THE VIRGINIA CONTINENTAL SLOPE. K. J. Sulak and J. A. Musick. Dept. of Ichthyology, VIMS, College of William and Mary, Gloucester Pt., VA 23062

Bottom trawl samples were obtained on the outer continental shelf, slope, rise and abyss off Virginia between depths of 50 and 5000 m. The demersal fish fauna comprised 189 species in 56 families. Dominant species pertained to the flatfishes (Bothidae, Pleuronectidae), as well as the Synaphobranchidae, Alepocephalidae, Zoarcidae, Halosauridae, Ophidiidae, Scorpaenidae and Triglidae. The fauna comprised predominantly euryphagous bottom dwellers, active benthos foragers and active nekton predators. Its species composition changed at a variable rate as a function of depth; sharp zonation was not apparent. Cluster analysis identified 11 species groups and 10 site groups. The most pronounced changes in faunal parameters occurred between 1500 and 2000 m. Numerical abundance and biomass decreased exponentially as a function of depth, while mean fish weight increased an order of magnitude between the shallowest and deepest site groups. Species diversity decreased dramatically and progressively between 1500 and 5000 m.

Bio. 69

HIBERNATION PATTERN OF THE UNITA BASIN GROUND SQUIRREL (SPERMOPHILUS ARMATUS). Margaret Sutherland and Jack A. Cranford, Biology Dept., Virginia Polytechnic Institute, Blacksburg, Va. 24061.

Unita basin ground squirrels were captured in the summer of 1977 from a population in Little Cottonwood Canyon 40 km southeast of Salt Lake City, Utah. Mean field hibernation cycles for adults in 1975-76 and 1976-77 were 225 days and 203 days in length. Hibernation cycles in 1978-79 and 1979-80 in the laboratory were shorter than field cycles, and may be attributed to nonhibernation periods in the burrow in the field. The internal organization of the hibernation period was composed of periodic arousals and bouts of deep heterothermy. Differences occurred between groups in some internal parameters. In 1978-79 hibernation occurred at the time field populations normally hibernate but in 1979-80 two different groups were created to determine if the annual hibernation cycle could be seasonally shifted. The control group was permitted to hibernate normally while the weight control group was not. For 6 to 8 months following arousal animals were prevented from gaining weight by food availability control. These animals entered hibernation during the spring instead of fall and were 6 months out of phase with the control group. No marked differences in hibernation period length, weight gain, weight loss or arousal patterns were noted.

Bio. 70

CULTURE OF IN VIVO FERTILIZED MOUSE EGGS. R. J. Swanson, J. W. E. Wortham, Jr., S. B. Ackerman, and P. J. Adams*. Dept. of Biological Sciences, Old Dominion Univ., Norfolk, VA 23508

In vivo fertilized eggs in various stages of early embryonic development were surgically removed from superovulated mice and cultured in vitro. Three strains of mice, two culture media, and two culture containers were evaluated for embryonic developmental effects. Data indicated that the two hybrid mouse strains examined ($CB6F_1$ and $B6CBAF_1$) exhibited superior in vitro embryonic development when compared to the outbred strain (CD-1). Optimal development was obtained using the combination of modified Kreb's Ringer bicarbonate medium with screw-top culture tubes compared to minimal development using the combination of Ham's F10 nutrient medium with organ culture dishes. The implication of this system in relation to quality control testing and experimental manipulations for the human in vitro fertilization procedure will be discussed.

Bio. 71

DYNAMICS OF A BLACK AND TURKEY VULTURE ROOST. T. M. Sweeney* and J. D. Fraser. Dept. of Fisheries and Wildlife Sciences, VPI & SU, Blacksburg, VA 24061.

A roost of black and turkey vultures (Coragyps atratus, Cathartes aura) near Radford, Virginia was observed weekly from 17 September 1981 to 23 March 1982. Vulture numbers were distributed bimodally over time with peaks of 498 and 793 on 21 September and 5 December. The ratio of black to turkey vultures ranged from 1.6:1 on 10 October 1981 to 4.0:1 on 12 January 1982. Most vultures left the roost trees from 20-90 minutes after sunrise and perched for 1 to 4 hours within 600 meters of the roost before leaving the area. Birds began ariving at the roost by 1200 and perched either in the roost or within 600 meters of it. Most birds entered the roost within one hour of sunset.

Bio. 72

SEXUAL MATURATION OF FEMALE PRAIRIE DEERMICE: INFLUENCE OF PHYSICAL VERSUS URINE CONTACT WITH GROUPED OR ISOLATED ADULT FEMALES.

C. Richard Terman, Laboratory of Endocrinology and Population Ecology, Biology Department, College of William and Mary, Williamsburg, VA 23185.

Female prairie deermice (Peromyscus maniculatus bairdi) were reared individually from weaning (21-24 days of age) until 40 days of age in physical contact with one adult female with two adult females or exposed to their urine. Other females were exposed only to distilled water. At 40 days of age females exposed to water averaged significantly larger ovaries and uteri than those reared in physical contact with one or two adult females ($P<.05$). Females exposed to the urine of these adult females did not have significantly smaller ovaries or uteri than those exposed to water. These data support earlier findings that physical contact between animals is of primary importance in retarding sexual maturation.

Bio. 73

A STUDY OF THE INFLUENCE OF VARIOUS PHYSICAL ENVIRONMENTAL FACTORS ON THE DISTRIBUTION OF SEVERAL MEMBERS OF THE BENTHIC MACROINVERTEBRATE COMMUNITY OF LAKE PEPIN, WISCONSIN. K. E. Trapp*, and A. L. Buikema, Jr., Dept. of Biology, Va. Polytechnic Inst. and State Univ., Blacksburg, Va. 24061.

The influence of several physical factors (depth, dissolved oxygen concentrations, % total organic matter, and sediment composition) on the distribution of three members of the macroinvertebrate community of Lake Pepin, WI was investigated. Benthic samples were collected twice during the summer of 1977 for a total of 243 samples. The distribution of the following taxa was examined: Chironomus plumosus, the Oligochaeta, and the Hirudinea. Simple linear correlation analyses indicated that invertebrate distribution was significantly influenced by the above physical factors and was often a function of feeding habit, physiological adaptations, and stage of larvae development. Multiple correlation analyses were conducted to determine the combined influence of the six physical factors on macroinvertebrate distribution. Significant ($\alpha = 0.05$) or highly significant ($\alpha = 0.01$) relationships were indicated for all taxa during one or both of the sampling periods. It may be concluded that the macroinvertebrates found in Lake Pepin were significantly influenced by the interaction of the physical factors examined.

Bio. 74

THE EFFECT OF SUPPLEMENTAL FOOD ON ARBOREAL SMALL MAMMALS IN THE DISMAL SWAMP

John W. Walke and Robert K. Rose, Departmental of Biological Sciences, Old Dominion University, Norfolk, Virginia 23508

To test the idea that food limits the density of small mammals in the Dismal Swamp, we added supplemental food (using tree-mounted nest boxes) to two forest plots, but not to two others. These pairs of experimental and control grids were placed in the forest on either side of a powerline right-of-way. Each 1.96 ha square grid had 64 nest boxes placed at 20 m intervals. Each nest box consisted of a #10 metal can with plastic lid, one 2.5 cm hole cut 4 cm from the bottom of the can, and hay for bedding; 100 g of mixed seeds and lab chow (2:1) was the supplemental food. Grids were checked regularly and rodent activity monitored by the detection of feces, the construction of nests, and the disappearance of food (in supplemented grids). Nest boxes were more frequently visited by rodents when supplemental food was present. Removal of the food decreased, but did not eliminate, visits to stations. Flooding on the grids lessened the activity of arboreal small mammals.

Bio. 75

INCIDENCE OF GLOCHIDIAL INFECTIONS ON FISHES IN THE NORTH FORK HOLSTON RIVER, VIRGINIA.

J. Widlak*, and R. J. Neves.* Dept. of Fisheries & Wildlife Sciences, VPI & SU, Blacksburg, VA 24061.

The parasitic relationship between the glochidia of fifteen freshwater mussel species and potential fish hosts was investigated at North Holston Ford (river mile 86.9) from June through December 1981. Fishes were collected by electrofishing twice monthly from seven consecutive 50 m sections and weekly from one section with a high density of mussels. The fins and gills of fishes were examined for glochidia at streamside; infected fish were preserved for subsequent enumeration of glochidia and identification to subfamily. A total of 3,761 fish representing 38 species were examined. Glochidia of the Unioninae were attached to twelve species of cyprinids, and glochidia of the Lampsilinae were attached to centrarchids (4 species), percids (5 species), and cottids (1 species). Glochidia of the Anodontinae were not found on any fish species, and no catfishes (3 species) or suckers (3 species) had attached glochidia. Unionine glochidia occurred on gill lamellae between June and mid-August, whereas lampsiline infections were observed on the gills, fins, and opercular flap of fishes from June through December.

Bio. 76

AN APICOMPLEXAN (PROTOZOA) IN THE ERYTHROCYTES OF THE RED BELLY WATER SNAKE.

William H. Yongue, Jr., Dept. of Biol., V.P.I.&S.U., Blacksburg, Va. 24061.

Four of five Natrix erythrogaster erythrogaster captured in the Virginia Beach region were positive for haemogregarine-like forms in their erythrocytes. The incidence was ca. 2/250 erythrocytes in the peripheral blood with the numbers somewhat higher in heart blood, heart tissue, lung and vertebral column. No evidence of growth, developmental stages, reproduction, nor transovarian transmission has been found. Sections from the vertebral column show a number of fully formed encapsulated extracellular forms that are rarely seen in peripheral blood. The crescent-shaped forms measure ca. 18 X 4 μm with a centrally to sub-centrally located nucleus that is ca. 2.5-3 μm long. Intracellular forms apparently cause liquefaction of the host cell's cytoplasm, generally displace the host cell's nucleus laterally and there is no evidence of necrosis in the fully matured erythrocytes. Transmission electron microscopy reveals a conoid, polar ring, rhopteries, micronemes (both anterior and posterior), 3 mitochondria anterior to the nucleus and 2 ranks of sub-pellicular microtubules.

Botany Section

HISTORIC LAND-USE CHANGE ON THE MISSOURI RIVER FLOODPLAIN IN NORTH DAKOTA. L.S. Andrews. Dept. of Biology, Va. Polytechnic Inst., Blacksburg, Virginia 24061

Deforestation rates since settlement were examined on a remnant section of the Missouri River Floodplain occurring between two reservoirs. The dams constructed two to three decades ago, have altered the hydrologic regime of the Missouri River which has had a major effect on the ecology of floodplain forests.

Analytical methods included interpretation of recent and archival aerial photographs, examination of General Land Office Survey records, and the examination of increment borings taken from various floodplain terrace stands.

Land clearing since settlement has claimed slightly more than half of the original floodplain forests. Irrigation practices have recently accelerated the clearing rate. River meandering has all but ceased, therefore the deposition of alluvium necessary for colonization by cottonwood and willow has been greatly reduced.

A SPLIT SEASON FOR THE INTRODUCTORY COURSE IN PLANT TAXONOMY. J. Rex Baird. Dept. of Biology, Clinch Valley College of the University of Virginia, Wise, VA 24293.

The increasing popularity of an academic calendar in which the spring semester ends in early May has caused problems for field botany and plant taxonomy courses because of the very brief time available for student experience with fresh flowering material.

A system of three eight-week courses, two semester hours each, has been developed to replace the traditional four semester-hour course. Two of these are Local Flora courses, offered at the beginning of the fall semester and at the end of the spring semester. Students enjoy the benefits of immediate hands-on study of fresh material. The third course emphasizes methods of systematic botany, may be adapted to interests of the students, and is offered in the off-season. The system has worked well at C.V.C. and has begun to attract non-biology students, especially elementary education majors. It may be of particular interest to instructors at small liberal arts colleges.

RESEARCH ON POSTHARVEST DISEASES OF CITRUS IN CALIFORNIA. A.B.A.M. Baudoin*, Dept. of Plant Pathology and Physiology, Va. Polytechnic Inst., Blacksburg, Va. 24061.

Recent trends in research on fungal storage diseases of citrus fruits will be discussed. In California, Penicillium digitatum and P. italicum (green and blue mold) are the major pathogens, while Geotrichum candidum (sour rot), Alternaria citri (stem-end rot), and Phytophthora spp. (brown rot) occasionally cause heavy losses. Biphenyl, orthophenyl phenol, 2-aminobutane, thiabendazole, and benomyl have come into widespread use in the past decades for the control of green and blue mold, but no satisfactory chemicals for the control of stem-end rot, sour rot, and brown rot have been available. One approach to avoiding storage losses due to these fungi is to identify fruit lots that are particularly prone to decay and to avoid storing such lots for extended periods. Methods to quantify the susceptibility of lemons to sour rot will be discussed, as well as the influence of physiological age and water status of the fruit on its susceptibility. The chemical control of blue and green mold has experienced considerable setbacks in recent years due to the development of fungicide resistance. Data on the prevalence of such strains, their development in competition with wildtype strains in the presence and absence of fungicides, and ways to manage resistance will be discussed.

TEACHING INTRODUCTORY PLANT PATHOLOGY LABORATORY AT THE UNDERGRADUATE LEVEL. A. B. A. M. Baudoin, R. Jay Stipes and J. A. Micales, Dept. Plant Pathol. & Physiol., Virginia Tech, Blacksburg, VA 24061.

It is highly desirable that a laboratory section accompany the lectures of a plant pathology course. This will provide the students with experience in the techniques used to diagnose diseases and to isolate, culture, and inoculate pathogens. Such a lab is easiest taught in the summer or fall, since a wide variety of fresh diseased material is then available in the field. But even in the winter, diseases can easily be demonstrated in a greenhouse and a variety of storage diseases of fruits and vegetables can be secured from grocery stores. In the plant pathology lab at Virginia Tech, students are asked to bring in their own diseased plant or plant part to use in exercises on diagnosis, isolation and identification of a pathogen, and proof of pathogenicity. Plant pathological processes that are easily studied include: transmission of viruses (e.g., Tobacco Mosaic Virus), infection of roots (Phytophthora parasitica on tobacco) and leaves (Helminthosporium sp. on corn), pathogenesis by toxins (Pseudomonas tabaci on tobacco) or pectolytic enzymes (Geotrichum candidum on citrus fruits), disease control by seed or soil treatment (damping off) and by foliar sprays (gray mold of ornamentals). A number of resource materials are available from several companies.

INTERESTING SOUTHWESTERN DESERT FUNGI. E. Castro-Mendoza* and O. K. Miller, Jr. Dept. of Biology, Virginia Polytechnic Institute and State University, Blacksburg, Va. 24061.

Several groups of Gasteromycetes are found in the southwestern deserts of North America. Secotioid fungi including Longula texensis, Montagnea arenarius, Podaxis pistillaris, and Endoptychum agaricoides are widely distributed. Neosecotium macrosporum, Gyrophragmium californicum, and Endoptychum arizonicum are more restricted in distribution. Support for the hypothesis that these secotioid fungi are closely related to agaricoid taxa in the Agaricaceae and Coprinaceae is provided by a study of the spores using scanning electron microscopy. The spores of L. texensis, E. agaricoides, E. arizonicum, and G. californicum are smooth and lack an apical germ pore. M. arenarius and P. pistillaris have smooth spores with large apical germ pores. The spores of N. macrosporum may be ornamented or smooth and lack an apical germ pore. Other gasteromycetes possessing adaptations for survival in a desert environment include Schizostoma laceratum, Phellorina unquinans, and Chlamydopus meyenianus. These taxa are generally placed in the Tulostomatales. Their taxonomy is discussed based on studies of their spores and tissue systems using light microscopy and scanning electron microscopy. (Supported by NSF grant 3230601)

LOCALIZATION AND ACTIVITY OF ENZYMES OF CARBON METABOLISM DURING THE INDUCTION OF CRASSULACEAN ACID METABOLISM IN MESEMBRYANTHEMUM CRYSTALLINUM. J.G. FOSTER, USDA, Appalachian Soil and Water Conservation Res. Lab., P. O. Box 867, Airport Rd., Beckley, WV 25801.

Mesophyll protoplasts, isolated from leaves of M. crystallinum performing either exclusively C_3 photosynthesis or pronounced Crassulacean acid metabolism (CAM), were prepared enzymatically. The intracellular localization of enzymes was studied by differential- and Percoll density gradient centrifugation of the protoplast extracts in which more than 90% of the organelles were intact, based on retention of marker enzymes. Experiments established the cytoplasmic location of phosphoenolpyruvate carboxylase (PEPC), enolase, phosphoglyceromutase, and NADP-malic enzyme; the mitochondrial location of NAD-malic enzyme; and the chloroplastic location of pyruvate, Pi dikinase. NAD-glyceraldehyde-3-phosphate dehydrogenase (G-3-P DH), phosphohexose isomerase (PHI), and phosphoglycerate kinase (PGK) were associated with both the cytoplasm and chloroplasts. Enzyme activities were higher in CAM extracts. Increases in total activity of G-3-P DH, PHI, and PGK upon induction of CAM were due to specific increases in the cytoplasmic forms of these enzymes; higher PEPC activity derived from increased net synthesis of enzyme protein. These results provide the basis for a proposed pathway for carbon flow in CAM plants. Support: USDA Competitive Grants 5909-0410-8-0088-9 and 59-2531-0-1-516-0 to Dr. G. E. Edwards.

INTERESTING AND UNUSUAL RUSSULA (AGARICALES) SPECIES FROM THE SOUTHERN ALLEGHANIES. G. F. Bills* and O. K. Miller, Jr. Dept. of Biology, Virginia Tech, Blacksburg, VA 24061.

A preliminary survey of the Russula flora of southwestern Virginia and southeastern West Virginia was made during the summer and fall of 1981. Russula granulata Peck, R. laurocerasi Melzer and R. aquosa Leclair are reported from West Virginia for the first time. Russula ballouii Peck, R. amoenolens Romagnesi and R. krombholzii Shaffer are reported from Virginia for the first time. Russula silvicola Shaffer is common throughout the region. Another Russula collection is apparently a new species. The morphology, taxonomy, habitat and distribution of these species is illustrated and discussed.

WILD FLOWERS ENDEMIC OF MOUNTAINOUS REGIONS AND ISLANDS OF GREECE. K.K. Hatzios, Dept. of Plant Pathology and Physiology, Va. Polytechnic Inst. and State Univ., Blacksburg, Va. 24061.

Greece is a country marvellously rich in wild flowers. This richness is a consequence of the wide range of habitats and climatic conditions of Greece, its geological history and its position in the Eastern Mediterranean region where plants from Eruope, Western Asia and North Africa intermingle. The flora of Greece includes at least 6,000 species with 700 of them being endemic of the mainland and islands of this country. Selected species of wild flowers endemic of a) the mountainous regions of Northern Greece and in particular of Mt. Olympus, b) the island of Crete and c) the Central and Southern Greece will be presented and discussed briefly. Such species of wild flowers will include orchids, tulips, anemones, campanulas, pansies, and cyclamens as well as other species endemic of these regions of Greece.

NOMENCLATURAL, CYTOLOGICAL AND MORPHOLOGICAL CONSIDERATIONS OF THE ENDEMIC STATUS OF SISYRINCHIUM BERMUDIANA L. (IRIDACEAE). L. Michael Hill, Dept. of Biology, Bridgewater College, Bridgewater, Virginia 22812.

The name Sisyrinchium bermudiana L. was first broadly applied to populations in North America, Bermuda and Europe. A careful nomenclatural review of the name demonstrated that it should apply only to the robust, large-flowered population endemic to the Bermuda islands. Published reports on the chromosome number of S. bermudiana L. are variable because the voucher specimens were collected in a variety of areas in both North America and Europe. The Bermuda population has never been studied from a cytological point of view.

The purpose of this investigation was to study, for the first time, the cytology of S. bermudiana in Bermuda. An attempt to compare this taxon with related species in Northeastern North America has also begun. Preliminary results indicate that the Bermuda population is unique both at the chromosomal level, as well as at the morphological level.

The study argues for the conclusion that S. bermudiana L. is endemic to the Bermudas and probably originated from ancestors in the Southern Hemisphere.

SEPARATION OF ENDOTHIA PARASITICA AND ENDOTHIA GYROSA BY THEIR UTILIZATION OF GALACTOSE AND SORBOSE. D. B. Janutolo and R. J. Stipes, Dept. Biol., Anderson College, Anderson, IN 46012, and Dept. Plant Pathol. & Physiol., VPI & SU, Blacksburg, VA 24061.

In an attempt to find nutritional differences between isolates of Endothia parasitica and Endothia gyrosa, we investigated the effect of carbon sources on vegetative growth. Galactose or sorbose was added to a basal medium (West Virginia Agr. Exp. Sta. Bull. 362T) to yield a final concentration of 5 gm carbon per liter. Three isolates from different geographical locations of both E. parasitica and E. gyrosa were used. Vegetative growth was measured after incubation periods of 7, 14, 21, 28, 35 and 42 days at 25C. The experiment was repeated 3 times with 5 replications per isolate per incubation period.

After an incubation period of 14 days, growth was significantly greater for all isolates of E. gyrosa than for isolates of E. parasitica when galactose was used as the carbon source. After an incubation period of 28 days, growth was significantly greater for all isolates of E. parasitica than for isolates of E. gyrosa when sorbose was used as the carbon source. Differences in the utilization of certain carbon sources possibly may be used in conjunction with other taxonomic criteria to delimit these taxa.

FACTORS INFLUENCING SUMMER-FALL PHYTOPLANKTON POPULATIONS IN THE LAFAYETTE RIVER ESTUARY. L. A. Kalenak* and H. G. Marshall, Depts. of Oceanography and Biological Sciences, Old Dominion University, Norfolk, Va., 23508.

Weekly surface samples were collected from four stations located in the Lafayette River, Virginia, from August to October, 1981. Salinity, water temperature, column depth, and Secchi depth were determined in the field. Laboratory analyses for ammonia, nitrates and nitrites, orthophosphate, reactive silicates, and phytoplankton cells were conducted. A non-hierarchical cluster analysis yielded a spatial variability in the data set. One group consisted of areas with well mixed waters. Characteristic of these stations were small-sized, chain-forming diatoms. Shallower areas with a less turbulent flow were also related significantly. Diatoms remained abundant, while flagellated cells representing a variety of taxa increased in number from summer to fall. Stations in two upper river branches formed distinct groups from stations downstream. Phytoflagellates were predominant, while diatom abundance was reduced in the branches, compared to downstream locations. The occurrence of blue-green cells was noted at these stations, with *Oscillatoria* spp. common. In all instances, a combination of nutrient concentrations and physical factors influenced the phytoplankton population structure.

VERTICAL DISTRIBUTION OF PHYTOPLANKTON FOR NANTUCKET SHOALS. L. A. Kalenak* and H. G. Marshall. Depts. of Oceanography and Biological Sciences, Old Dominion University, Norfolk, Va., 23508.

Phytoplankton samples were taken at various depths at twelve stations along a transect in the area of Nantucket Shoals. A total of 126 species were identified using a modified Utermohl method. At all station depths, an unidentified ultraplankton component was dominant in number. Also of importance due to their high concentrations at surface stations over the shoal region were several diatom and blue-green species (*Rhaphoneis amphiceros*, *Nitzschia* spp. and *Nostoc commune*). Surface samples outside this area had increased concentrations of coccolithophores (*Emiliania huxleyi* and *Rhabdosphaera hispida*). Lower depths indicated higher concentrations of *Cryptomonas* sp. Total cell numbers were relatively high in surface waters, reaching a maximum of 2.7 million cells/l. However, highest concentrations were generally found at a depth of five meters. Below this, cell numbers steadily decreased. There was a transition of dominance over the shelf with small sized diatoms and other species most abundant, with larger sized species (>100 μm) more common at mid-shelf stations, with the smaller sized forms again prominent near the shelf break. This study was supported in part by funds from the NOAA/NEMP Ocean Pulse program.

SECONDARY SUCCESSION IN SHENANDOAH NATIONAL PARK: COMPOSITION OF MESIC AGGRADING PLANT COMMUNITIES. M. L. Lipford* and W. D. Cocking. Dept. of Biology, James Madison University, Harrisonburg, VA. 22807

Forest community composition in 20 stands positioned on northwest and southeast slopes at elevations of 910 and 720 m have been sampled quantitatively using 5 x 20 m quadrats. At present, the forested area within Shenandoah National Park is characterized by numerous seral stages distributed along altitudinal gradients on various aspects of the mountain slopes. This is the result of complex prior land use patterns. The stands which were studied are of intermediate successional age (80 - 120 yrs.) and include large canopy tree individuals which were omitted from two or more timber harvests within the past century. These "mixed-age" stands exhibit a great deal of site to site variability. Several deciduous forest species occur as co-dominants in these stands along with residual populations of early successional species such as Robinia pseudo-acacia L., Fraxinus americana L. and Prunus serotina Ehrh. which are greatly reduced in their importance. The results of this study characterize the composition of forests having widespread current distributions within the park.

PHYTOPLANKTON DYNAMICS OF THE UNITED STATES NORTHEASTERN CONTINENTAL SHELF. H. G. Marshall. Dept. Biological Sciences, Old Dominion University, Norfolk, Va. 23508.

Phytoplankton samples were analyzed from 20 cruises, at 604 stations, located over the continental shelf and collection between 1978 and 1981. A diverse phytoplankton population (446 species), dominated by diatoms and an ultraplankton component, was noted with distinct regional and seasonal assemblages. Maximum concentrations and biomass occurred from winter to spring, decreasing in summer, to rise again in fall. Highest cell concentrations and biomass were at near shore stations and areas downstream from major estuaries. The mid-shelf region was more variable in composition and biomass, with areas along the shelf break also having increased cell numbers and biomass. Other areas of high productivity included Georges Banks, coastal regions in the Gulf of Maine, off lower New York bay and the North Carolina coast. Successional patterns were evident and frequently repeated. Patchiness was common, as was an ultraplankton component (<10 µm) apparently composed of cyanophycean and chlorophycean species. Estuaries and coastal marshes were recognized as sources for various species to shelf waters. Supported in part by the NOAA-NEMP program of Ocean Pulse.

OBSERVATIONS ON THE VASCULAR FLORA OF THE FALKLAND ISLANDS. Peter M Mazzeo, Herbarium, U.S. National Arboretum, Washington, D.C. 20002.

The vascular flora of the Falkland Islands, situated about 250 miles east of southern Argentina in the South Atlantic, is greatly restricted by adverse weather conditions. Accordingly, the Falkland landscape is somewhat monotonous with primarily grasses, "cushion" herbaceous plants, and few woody species creating various plant communities. On the whole, the flora is represented by some 163 indigenous species and some 40 exotic species of vascular plants that have been introduced to the islands since habitation by man.

The tussock grass, Poa flabellata, was the most common and conspicuous vascular species originally found on the islands; however, with the coming of man, much of this unique southern hemisphere plant was destroyed mostly by sheep and some cattle grazing. Today, efforts are being made to replant and restore some of the tussock formation.

The woody flora is most limited to relatively few taxa such as the diddle-dee, Empetrum rubrum, and related heath species. Gorse, Ulex europaea, originally introduced as "fences" to control sheep grazing, has now become well established on the islands. The largest species there today is the introduced Monterey cypress, Cupressus macrocarpa, commonly windblown and persisting about homesites and protected areas.

THE EFFECTS OF FLOW RATE ON GROWTH AND SPORULATION OF DIALYSIS CULTURES OF ANABAENA VARIABILIS AND A. CYLINDRICA. P. J. Mc Nerney , J. W. Scott and J. E. Wilson. Va. State Univ., Petersburg, Va. 23803

Growth of both species is increased by dialysis culture. No difference in growth is detected in either species at flow rates of 40 ml and 100 ml/hr. Sporulation is significantly less in dialysis cultures of A. variabilis than in batch cultures. Sporulation appears sooner in batch cultures than in dialysis cultures.

SEPARATION OF ENDOTHIA PARASITICA AND E. GYROSA ON THE BASIS OF THEIR DIFFERENTIAL SENSITIVITY TO THIABENDAZOLE HYPOPHOSPHITE. J. A. Micales and R. J. Stipes. Dept. Plant Pathology and Physiology, Virginia Tech, Blacksburg, VA 24061

The selective toxicity to 2-(4-thiazoyl)benzimidazole hypophosphite (Arbotect®-20S) was used to differentiate Endothia parasitica from E. gyrosa. The compound was incorporated into 0.5% glucose-0.1% yeast extract-1.5% agar, and the radial growth of ten specimen-vouchered isolates was determined after 15 days. The growth of E. parasitica was not influenced at 0.5 µg/ml, while the percent growth inhibition of E. gyrosa ranged between 18-50%. At 1.0 µg/ml, the growth of E. parasitica was totally suppressed, while that of E. gyrosa was decreased by 55-85%. This information can be utilized to construct a differential medium by which the two species of Endothia which are common in Virginia can be rapidly and efficiently separated.

DISTRIBUTION OF PSEUDOMONAS SYRINGAE IN ULMUS AMERICANA FOLLOWING ADMINISTRATION BY INFUSION. J. A. Micales, R. J. Stipes and G. H. Lacy. Dept. Plant Pathology and Physiology, Virginia Tech, Blacksburg, VA 24061

The inoculation of American elms (Ulmus americana) with the bacterium Pseudomonas syringae has recently been publicized as a biological control agent for Dutch elm disease. In order to serve as a control agent, the bacterium must first be translocated throughout the tree and subsequently recovered. To determine whether this is possible, a 10% suspension of P. syringae, made from lyophilized powder, was passively administered to 12 8-10 year-old field plot elms (DBH 5.2-13.7 cm). Lateral branches were sampled for the presence of P. syringae at the time of inoculation and at two and four weeks later. Colonies were recovered from one tree at the time of inoculation and were not obtained at later dates. The abilities of the bacterium to be translocated, survive and even reproduce throughout the tree, and to serve as an effective control agent, are seriously questioned.

HYPOGEOUS MYCORRHIZAL FUNGI FROM THE SOUTHEASTERN UNITED STATES. S. L. Miller*, and O. K. Miller. Dept. of Biology, Virginia Tech, Blacksburg, Va 24061.

Infrequently encountered hypogeous fungi from the southeastern United States were collected, and attempts made to determine mycorrhizal relationships. Hydnotria cubaespora and Balsamea sp. were found attached to roots of eastern hemlock. Close association with the roots indicated that they are putative ectomycorrhizal species. Abundant sporocarps of Tuber shearii were found under pure eastern white pine. Mycorrhizae collected in the proximity of the sporocarps exhibited a tightly woven mantle of textura globosa, similar to tissue in the exoperidium of T. shearii. Elaphomyces muricatus was collected under a variety of broadleaved trees. Mycorrhizal root tips found imbedded in the exoperidium indicate probable mycorrhizal relationships. Rhizopogon vulgaris, found on mining spoil in West Virginia was closely associated with the roots of red spruce. Zelleromyces ravenellii was collected in the Piedmont of South Carolina, under shortleaf pine. Pure tissue isolates were made using a peat-vermiculite medium, and used to achieve synthesis with shortleaf pine. Abundant bufurcate mycorrhizal rootlets were produced, confirming that Z. ravenellii is an ectomycorrhizal species. Close association of hypogeous fungi with forest trees and formation of mycorrhizae in laboratory synthesis indicate that many hypogeous fungi in the southeastern United States are ectomycorrhizal.

CHESTNUT-OAK (QUERCUS PRINUS L.) DISTRIBUTION IN THE VIRGINIA PIEDMONT AS AN AID TO GEOLOGIC MAPPING. N.M. Milton and M.D. Krohn* MS 927, U.S. Geological Survey, Reston, Va. 22092.

Geologic mapping in humid regions such as the eastern United States is complicated by heavy vegetation cover and a sparsity of outcrops. Distribution of certain disjunct plant species can be used to identify changes in the underlying lithologies. The Virginia Piedmont is underlain by NE-trending metamorphosed sedimentary, volcanic, and volcaniclastic units, which are intruded by several granitic plutons. Upland gravel deposits are common, especially along the Fall Line. In most areas, a thick layer of saprolite covers bedrock. In the present study, several canopy species were mapped by foot and road traverse in two areas of the Piedmont: along the James River near Midlothian, Va., and along the Rappahannock River in Spottsylvania Co. Several east-west traverses were made between these two study areas. Of the species examined, chestnut-oak (Quercus prinus L.) has a distribution most closely related to geology. Chestnut-oak is highly coincident with highly weathered, well-drained terrace gravel deposits and with certain metavolcanic rocks. The most likely factor controlling the distribution is water availability, which is limited in each lithologic type. The chestnut-oak areas were distinguishable on an enhanced Landsat multispectral scanner image, indicating the possibility of using satellite imagery as an aid in geologic mapping.

THE VASCULAR FLORA OF EASTERN MIDDLESEX COUNTY, VIRGINIA. Gretchen Barrow North. Dept. of Biology, College of William and Mary, Williamsburg, Va. 23185.

A study of the vascular flora of eastern Middlesex County, Virginia was begun in March, 1981 and continues to the present time. The study area, covering approximately sixty square miles, is bordered on the east by the Chesapeake Bay, on the north by the Rappahannock River, on the south by the Piankatank River, and on the west by U. S. Route 17. Principal habitats include salt and freshwater marshes, swamps, coastal strands, mixed pine-deciduous woods, and disturbed areas. To date, 668 taxa have been collected and identified, notable among them being Lechea maritima var. virginica, a species listed by the U. S. Fish and Wildlife Service as endangered; Anoda cristata, found in only three other Virginia locations; and four species apparently at or near their northernmost limits, Ponthieva racemosa, Malaxis spicata, Crataegus flava, and Rhexia nashii. The phytogeography of the area is discussed, noting the percentages of circumboreal, Eastern Asian, tropical, cosmopolitan, and introduced species, as well as the distribution patterns of U. S. species. Comparisons are made between the phytogeographical affinities of four Coastal Plain regions: the upper, middle, and lower peninsulas and the area south of the James River, with particular emphasis on species attaining their northernmost limits in these regions.

SECONDARY SUCCESSION IN SHENANDOAH NATIONAL PARK: COMPOSITION OF POTENTIAL MATURE STEADY STATE PLANT COMMUNITIES. R. H. Gwermohle, Jr.* and W. D. Cocking Dept. of Biology, James Madison University, Harrisonburg, VA. 22807

Forest tree strata in 9 undisturbed, mature stands located on southeast facing slopes in Shenandoah National Park have been quantitatively sampled at elevations of 910, 720 and 590 m. The species composition and structure of these stands may be indicative of the eventual composition at maturity of the various aged successional forests now developing within the park.

Community species composition and species importance in canopy (20+ cm dbh), understory (10.0 - 19.9 cm dbh), and sapling (2.5 - 9.9 cm dbh) class strata varied with elevation. Quercus rubra L., Q. prinus L., Q. alba L. and Carya spp. Nutt. are the major canopy species at all elevations based on relative importance values. Liriodendron tulipifera L. is an additional canopy component at the lower two elevations, but is rare at 910 m. In the understory stratum, Acer rubrum L., Fraxinus americana L., Ostrya virginiana (Mill.) Koch. and transgressives of the canopy species are of varying elevational importance. At 910 m the primary component of the sapling stratum is Hamamelis virginiana L. while at 720 and 590 m Cornus florida L. very abundant. Castanea dentata (Marsh.) Borkh. is still present in the small size class.

OCCURRENCE OF AQUATIC PHYCOMYCETES IN ALASKAN TUNDRA. R. A. Paterson. Dept. of Biology, Va. Polytechnic Inst. and State Univ., Blacksburg, VA 24061

During August, 1979, 72 samples were collected from soils in the Eagle Creek Region of Alaska. Samples were taken from the upper soil surface at points along transects and from horizons of soil profiles. Plankton samples were collected from Birch Creek and examined for the presence of parasites of algae. Cultures were prepared for isolation and identification of aquatic Phycomycetes by submersing soil in water-filled culture dishes and adding "baits" typically used in the study of these fungi. It appears that members of the Chytridiomycetes and species of Pythium are the dominant forms in Alaskan soils studied. These fungi occur more frequently and with more diversity in the surface soils of intertussock areas than in tussocks. Further, they are present in soil horizons where the organic carbon is high and decomposition has occurred and do not occur in the bottom horizons that are composed of silt loam with low organic matter. There is some indication that occurrences and distribution of these fungi may be related to such factors as pH, temperature, moisture, and bulk density. Parasites of phytoplankton are common.

DISTRIBUTION OF PINUS VIRGINIANA IN THE PENINSULA OF VIRGINIA. Cindy Larson Rice and Stewart Ware. Dept. of Biology, College of William and Mary, Williamsburg, VA 23185.

Virginia (Pinus virginiana) and Loblolly (P. taeda) pines are both abundant between the James and York Rivers. Studies by R. Monette and S. Ware found loblolly pine to be overwhelmingly dominant in old field succession, with Virginia pine absent or rare even when seed trees of Virginia pine were nearby. In our survey we found the same results, and found Virginia pine to be abundant in areas that had been heavily (selectively) timbered (perhaps by cutting out an earlier generation of pine), had been clearcut but not further managed, or had been bulldozed off so that the red topsoil was exposed (sloping road cuts, for instance). Loblolly pine ranged from almost abundant (usually) to absent (rarely) in these same sites. Despite the clear association with past land use, neither pH, Ca, Mg, K, P, or growing season moisture (measured at 2-week intervals with Bouyoucos moisture meter) correlated with abundance of the two species.

NEW DISTRIBUTIONAL RECORDS FOR SOME VIRGINIA PLANTS. Martha K. Roane, Dept. of Plant Pathology & Physiology, Va. Polytechnic Inst. & State Univ., Blacksburg, VA 24061.

The following species not recorded in the Atlas of Virginia Flora for Montgomery County are reported as occurring there: Agropyron repens, Festuca elatior, Muhlenbergia mexicana, Cornus stolonifera, Gaultheria procumbens, Juglans nigra, Malva rotundifolia, Plantago major, Portulaca oleracea, Paulownia tomentosa. Not recorded in the Atlas for Pulaski County but here reported are Cornus stolonifera, Paulownia tomentosa and Dicentra cucullaria. Similarly unreported in the Atlas for Giles County, but here reported are Cornus stolonifera, Miscanthus sinensis, Gentiana andrewsii. Many of these have been reported in Massey's Virginia Flora but not noted in the Atlas of Virginia Flora.

TEACHING INTRODUCTORY PLANT PATHOLOGY THEORY AT THE UNDERGRADUATE LEVEL. R. J. Stipes, A. B. A. M. Baudoin and J. A. Micales, Dept. Plant Pathol. & Physiol., Virginia Tech, Blacksburg, VA 24061.

The science of plant pathology, begun in Europe, is a little over 100 years old, and even though it had its genesis more in fields and granaries than in halls of ivy, it now embraces--through a long period of evolution---very basic as well as pragmatic aspects. Phytopathology, or dysfunctional plant physiology, is eclectic, and draws upon a broad spectrum of botanical, zoological, microbiological and physical sciences. All 51 departments of plant pathology in land-grant universities in the U.S.A. offer undergraduate plant pathology; however, it is becoming quite popular as an option in biology departments in several non-land-grant schools. After plant identification, the next most common inquiry is the cause of plant disease. Plant pathology can be taught from the basis of (1) diseases of the host plant, (2) classes of causal agents (biotic, abiotic), (3) physiological functions affected (water/food translocation, photosynthesis, etc.) or (4) from a conceptual standpoint. A liberal selection of resource materials (literature, slide sets, etc.) is available from The American Phytopathological Society, St. Paul, MN. Plant pathology not only broadens the pure botanical training, but enhances employment possibilities for the undergraduate.

THE GENUS COLLYBIA IN VIRGINIA. Rytas J. Vilgalys*, G.F. Bills*, and Orson K. Miller, Jr. Dept. of Biology, Virginia Polytechnic Institute and State University, Blacksburg, Va. 24061.

The genus Collybia (Fr.)Kumm. is well represented in the mycoflora of Virginia. The genus is divided into 5 sections: sect. Collybia, sect. Striipedes, sect. Vestipedes, sect. Subfumosae and sect. Levipedes. Members of each section which occur in Virginia are discussed. In addition, several taxa are reported as new records for the state of Virginia. These include C. kauffmanii Halling, C. polyphylla (Pk.)Singer, C. dichrous (Berk. and Curt.) Gilliam, C.luxurians Peck, C. cookei (Bres.)Arnold, C. earleae (Murr.)Murr., C. dryophila var. funicularis (Fr.)Halling, and an unnamed species of Collybia closely related to C. dryophila.

Chemistry Section

INTERACTION OF VAPORS AND LIQUIDS WITH COALS. Hani Awad* and J. P. Wightman, Chemistry Dept., Va. Polytechnic Inst. and State Univ., Blacksburg, VA 24061

The adsorption isotherms of methanol, ethanol and propanol from the vapor phase were measured for Amax and Pocahontas coals. The uptake of alcohols on the surface of Amax coal was effected by the outgassing temperature and the uptake increased with increased outgassing temperature. Pocahontas coal showed no change in uptake of the alcohols by increasing the outgassing temperature. Heats of immersion of Amax coal in the homologous series of n-alcohols were determined in a Calvet microcalorimeter. The heats of immersion and the rates of immersion on the Amax coal showed significant differences from the heats and rates of immersion of Pocahontas coal. Different surfactants were added to water to reduce its surface tension and thereby enhance the wetting rate of the Amax coal particles by water. ESCA and IR spectra were obtained to further characterize the surface.
[Work supported in part under SMMRRI at VPI&SU]

THE REACTION OF SOME O-SUBSTITUTED ANILINES WITH VARIOUS α,β-ACETYLENIC KETONES. R. G. Bass and M. S. Sinsky, Dept. of Chem., Va. Commonw. Univ., Richmond, Va. 23284.

The reaction of some o-substituted anilines with various α,β-acetylenic ketones was examined as a route to 4-alkyl, aryl, hydroxy, and amino-3-quinolyl ketones. The anilines examined were 2-aminoacetophenone (1), 2-aminobenzophenone (2), anthranilonitrile (3), methyl anthranilate (4), and ethyl anthanilate (5). The acetylenic ketones used were dibenzoylacetylene (6), benzoylphenylacetylene (7), 3-butyn-2-one (8), and 4-phenyl-3-butyn-2-one (9).

Each of the acetylenic ketones reacts with the anilines to give enamines; however, exceptions were found. Dibenzoylacetylene (6) reacts with 3 to give the enamine along with a small amount of 4-amino-2,3-dibenzoylquinoline. The reaction with 1 and 2 gives the respective quinolines directly. Benzoylphenylacetylene (7) reacts with 2 to give 3-benzoyl-2,4-diphenylquinoline directly, but no reaction occurs with 1 and 3. 4-Phenyl-3-butyn-2-one (9) does not react with 1, 2, and 3. The enamines exist as the intramolecularly hydrogen bonded isomer.

The enamines, except those from anthranilonitrile, undergo cyclization with a 5:1 molar excess of methanolic sodium methoxide to give quinoline derivatives. The 4-quinolinols exist predominantly as the 4-quinolinone tautomer.

NMR ANALYSIS OF BORNEOL AND ISOBORNEOL. SPECTRA-STRUCTURE CORRELATIONS. Harold M. Bell, Dept. of Chemistry, Virginia Polytechnic Inst. and State Univ., Blacksburg, VA 24061.

The ^1H NMR spectra of borneol and isoborneol have been analyzed. Borneol spectra both at 200- and 300 MHz were non-first-order, but were amenable to analysis by conventional techniques, including program LAOCOON. The chemical shift reagent $Eu(dpm)_3$ was used in an effort to simplify the spectrum. However, the splitting remained complex, owing to the near-identical shifts of endo-5-H and exo-6-H. Analysis of the isoborneol spectrum was not possible, even at 200 MHz, owing to the near-proximity of several chemical shifts. However, treatment with a small amount of $Eu(dpm)_3$ gave a well-defined spectrum, which, although still non-first-order, was readily analyzed. Some success has been realized in correlating chemical shifts and coupling constants with structure. Use of Allinger's molecular modeling program, MM2, has provided insight into the subtle structural changes imparted to the bicyclo[2.2.1] heptane system by the methyl and hydroxyl substituents.

BEATING THE TRAUMA OF ORGANIC CHEMISTRY--DOES PREPARATION HELP?
L. D. Berg, No.Va.Comnty.Col, Annandale VA 22003

Success in Organic Chemistry has been a major concern for the chemistry student and professor for many decades. Large numbers of students withdraw, fail, and/or repeat this course. Most courses of study have pre-requisites, but Organic Chemistry is often entered without sufficient background.

In an effort to remedy this inadequacy, INTRODUCTION TO ORGANIC CHEMISTRY, CHEM 140, 2 quarter hours credit, has been offered at NVCC, with the intent of preparing the student for the regular Organic Chemistry course.

The contents of this course includes NOMENCLATURE, STEREOCHEMISTRY, MECHANISMS, RESONANCE, and briefly, SPECTROSCOPY (NMR, IR, MS, UV). These topics are felt to be the most important 'new' ideas which have not been introduced in previous chemistry courses, but are needed early in Organic.

Evaluation of the course has been made by students continuing at colleges throughout Virginia and elsewhere. General satisfaction with the course is expressed and evidenced with grades of A and B being most often earned. The desire for more "reactions" and lab experience is requested, but cannot be included in such a short course.

High school seniors are allowed to enroll, being especially encouraged by their teachers in the absence of an organic course in their own school.

HYDROPHOBIC CHROMATOGRAPHY OF BMV AND OTHER ISOMETRIC VIRUSES. Sandra Boatman and Nandini Tandon, Dept. of Chemistry, Hollins College, VA 24020

The purpose of this research is to determine whether hydrophobic chromatography on alkyl agaroses (Sigma) can be used to assess the surface hydrophobicities of brome (BMV), cucumber (CMV), southern bean (SBMV) and turnip yellow (TYMV) mosaic viruses. Samples (0.10 mg) of viruses in 0.02M sodium acetate pH 5.0 containing 0.5M sodium sulfate (Na_2SO_4) or chloride (NaCl) were applied at 20C to 1.0 ml columns of butyl (BA) or hexyl (HA) agarose equilibrated in and eluted with the same solution. Virus quantities were determined by UV absorbance. In 0.5M Na_2SO_4, significant differences were observed among the affinities of the four viruses for BA with TYMV binding the most strongly, BMV the least. This may indicate that BMV has the least and TYMV the most hydrophobic surface. In NaCl, however, BMV had a significantly higher affinity for BA than TYMV did. The affinities of BMV and TYMV for HA were not significantly different in 0.5M NaCl. While TYMV's affinity for BA was significantly less than its affinity for HA, BMV's affinity for BA and HA did not differ significantly. This difference between TYMV and BMV indicates either that they bind to alkyl agaroses by different mechanisms or that their alkyl-binding sites are constituted differently. Hydrophobic chromatography should be useful for comparing hydrophobicities of virus surfaces.

CHEMICAL AND SPECTRAL ANALYSIS OF THE AMIDE DERIVATIVES OF SOME OF THE DICHLOROBENZOIC ACIDS. Yvonne E. Bobiak, Samuel J. Gamble. Dept. of Chemistry, Lynchburg College, Lynchburg, Va. 24501

This paper deals with the synthesis and analysis of the obtained amide derivative of 2,4-dichlorobenzoic acid. The amide derivatives of 2,4-, 2,5-, and 2,6-dichlorobenzoic acids were analyzed using the Na fusion test for Nitrogen and IR and UV instrumentation for functional group verification. The amides were produced by refluxing the acid with $SOCl_2$ and then addition to ice cold NH_4OH. Recrystallization with ETOH and H_2O followed. The melting points obtained are 2,4- 191.5-192°C; 2,5- 157°C; 2,6- 202°C. The IR data verify the amide group with distinct peaks at 3300-3400 cm^{-1} and the carbonyl peak at 1675-1700 cm^{-1}. The UV data exhibits a broad peak at 220nm.

No substantial information has been found verifying a solid amide derivative for 2,4-dichlorobenzoic acid. Information has been obtained for both 2,5- and 2,6-dichlorobenzamides verifying the obtained experimental data.

ANALYSIS AND PURIFICATION OF OPTICAL FIBER HALIDES. D. Bivings Bonham* and Benjamin P. Huddle. Dept. of Chemistry, Roanoke College, Salem, Va. 24153

The purity of $SiCl_4$, $GeCl_4$, and $POCl_3$ used in the manufacture of optical fibers was investigated using long-path infrared spectroscopy. Interest was centered on hydrogen-bearing impurities, as they are known to contribute to attenuation in optical fibers. Major impurities identified included hydroxyl and HCl contaminants, which are related to hydrolysis, and hydrocarbon and hydride impurities, which originate in the manufacturing process.

In addition, the purification of these chemicals was accomplished in a sealed system, under a thoroughly dried atmosphere of nitrogen, using photochemical chlorination, reaction with PCl_5, and nitrogen bubbling. Infrared spectroscopy was again used in this process to monitor the progress of the purification scheme and determine the relative success of the steps in the procedure. Analysis indicated nearly complete removal of the hydride, the hydroxide, and hydrocarbon constituents, in addition to any volatile impurities such as HCl and CO_2.

STERIC INFLUENCES OF THE HYDROPEROXIDE ON THE EPOXIDATION OF 2,5-DI-tert BUTYLBENZOQUINONE. Sarah Clements* and E. M. Hairfield. John Baker Daffin Lab. of Chemistry, Mary Baldwin Col., Staunton, VA 24401

This research analyzes the effect on the rate of epoxidation of 2,5 di-tert butylbenzoquinone and the effect of varying the dielectric constant of the solvent on the rate of the reaction. Epoxidation utilizing t-butylhydroperoxide yielded cis and trans diepoxides in a 7:3 ratio whereas the cumene hydroperoxide yielded only 60% of the cis diepoxide. A possible explanation involves the steric requirements of each hydroperoxide. Furthermore, the rate of epoxidation is decreased for the reaction with cumene hydroperoxide. We interpret these results in terms of the three-dimensional shapes of the reacting molecules. The reaction was carried out in a dioxane-alcohol mixture. Increasing the polarity of the solvent causes a small decrease in the rate of reaction, as predicted.

OLIGO G - OLIGO C RNA DUPLEX STRUCTURE? Steven R. Davis, T. O. Sitz. Department of Chemical Sciences, Old Dominion University, Norfolk, VA 23508

Naturally occuring RNA molecules contain both single and multiple stranded regions. The stability of duplex regions can be determined by measuring the temperature required to denature the helix. Borer et.al. (J. Mol. Biol. 86, 843) has presented a model to predict the stability of RNA duplexes, which works well except for duplex regions of predominately G, C content. Therefore, an investigation of the stability of oligo G - oligo C duplexes has been undertaken. Oligomers of G and C were formed by base hydrolysis of the respective polymers. Separation according to chain length was achieved by DEAE Sephadex A-25-120 column chromatography with a NaCl gradient containing urea. The respective oligomers were purified by subsequent anion-exchange chromatography and lyophilization. However, formation of the G, C duplex was complicated due to the formation of a very stable G self-structure. In order to overcome this, 1:1 mixtures of oligo G_n-oligo C_n on H_2O were heated to 95°C to dissociate the G self-structure. NaCl was added and the solutions allowed to cool. Analysis for duplex formation thus far was by DEAE Sephadex A-25-120 column chromatography, U.V. spectra and thermal denaturation studies. Spectral changes were observed on comparison of spectra below and above the Tm. These changes proved to be reversible upon cooling, with the rate proportional to the chain length. Tm temperatures were compared with those of G and C alone.

PREPARATION OF 6-MECAPTOPURINE DERIVATIVES FOR INCORPORATION INTO LIPOSOMES. S.P. Geary, M.A. Pleva, R.H. Waymouth, J.K. Shillington*, T.A. Wilson (*Academy Member), Dept. of Chemistry, Washington & Lee Univ., Lexington, VA 24450

The use of liposomes as carriers of therapeutic agents is well established. Water-soluble and lipid-soluble agents can be effectively incorporated into liposomes. Previous studies on the incorporation of 6-mecaptopurine were discouraging due to the poor solubility of that drug in water and lipids. Present research focuses on the acylation and alkylation of 6-mecaptopurine to increase its solubility in lipids. Multilamellar, phosphatidylcholine/cholesterol liposomes are used to incorporate the 6-mecaptopurine derivatives. Separations of free drug from liposome-encapsulated drug can be achieved by Sephadex G-50 gel filtration.

THE REACTIONS OF HALOPHOSPHAZENES WITH ALKYLLITHIUM REAGENTS. Paul J. Harris and Cindy L. Fadeley*. Department of Chemistry, Va. Polytechnic Institute, Blacksburg, Va. 24061-0699

In order to synthesize new poly(organophosphazenes) the reactions of many different organometallic reagents with halophosphazenes have been examined. As polymer reactions can be extremely complex, many of these studies have been performed on the cyclic "model" compound hexachlorocyclotriphosphazene, $N_3P_3Cl_6$. Grignard and organocopper reagents are found to react with hexachlorocyclotriphosphazene by a "metal-halogen" exchange pathway. This chemistry will be reviewed. Organolithium reagents on the other hand are found to react totally differently with hexachlorocyclotriphosphazene. The predominant reaction pathway for these reactions is clevage of the P-N ring accompanied by trace amounts of ring substituted products, (mono and di-methylchlorocylcotriphosphazenes). All these products result from an initial nucleophilic attack at phosphorus by the organometallic reagent. However, the direction of attack apparently dictates the final products composition. These reaction mechanisms will be disucssed.

OXYGENATION KINETICS OF MANGANESE(II) SCHIFF BASE COMPLEXES. Fred C. Frederick* and Larry T. Taylor, Virginia Polytechnic Institute & State Univ., Department of Chemistry, Blacksburg, VA 24061.

The reaction of molecular oxygen and manganese(II) complexes containing ligands condensed from salicylaldehyde and linear diamines has previously been studied both in solution and in the solid state. It was postulated that the reaction proceeded via a two-step overall mechanism, passing through an isolable Mn^{III}-O^{2-}-Mn^{III} intermediate on the way to the fully oxygenated $Mn^{IV}<(O^{2-})_2>Mn^{IV}$ product. Relative rates of oxygenation of the various complexes were studied qualitatively by visual observation. We have now extended this work to include a quantitative kinetic study. Data were generated by following changes in the UV-visible spectrum of the complex as oxidation occurred. Calculated kinetic parameters (rate constants and activation energies) will be presented and correlated with ligand modifications and solvent changes.

A NOVEL ENTRANCE TO THE PROPELLANE SERIES. S.W. Hall, M.A. Pleva, J.K. Shillington*, R.W. Young (*Academy Member) Dept. of Chem., Washington & Lee Univ., Lexington, VA

Recent investigations of the literature have revealed two easy methods for the preparation of the $\Delta^{9,10}$ octalin-1,5-dione. This happens to be the activated dienophile in our proposed Diels-Alder condensation with a diene such as 1-acetoxy-1,3-butadiene to effect a synthesis of propellane. The method we are currently using was adapted from McChesney et.al, a method that involves 1,5-Decalindione. The activated dienophile is obtained from this compound via elimination of HBr from a 9,10-hydrohalo intermediate. With the production of this dienophile in large amounts, we are currently investigating the Diels-Alder condensation of this compound with 1-acetoxy-1,3-butadiene.

KETONE SUBSTITUTED PHOSPHAZENES. Paul J. Harris, Dept. of Chemistry, Va. Polytechnic Institute, Blacksburg, Va. 24061-0699

The reactions of halophosphazenes with organometallic reagents are extremely complex and often result in clevage of the phosphazene skeleton. In order to try to circumvent these problems, the reactions of enolate anions with halophosphazenes were investigated in an attempt to synthesize "C" alkylated phosphazene products. However, all the reactions that were studied led exclusively to "O" alkylated products possessing an enol-ether group bound to phosphorus.

In order the synthesize keto-substituted phosphazenes the reverse type reaction was utilized i.e. the reaction of a phosphazene anion with an α-haloketone or precursor. These reactions led through some interesting intermediates and this chemistry, along with that of the keto- substituted phosphazenes will be discussed. (Aided by a grant from the Research Corporation)

FURTHER STUDIES OF THE NENITZESCU 5-HYDROXYINDOLE SYNTHESIS. Joi L. Phelps* and James B. Patrick. John Baker Daffin Dept. of Chemistry, Mary Baldwin College, Staunton, Virginia 24401.

Further studies of the nitromethane modification of the title reaction as reported previously, using benzo- or toluquinone and methyl or ethyl esters of β-amino- or β-alkylaminocrotonic acid, have revealed an increasing number of anomalous differences between the behavior of the methyl and the ethyl esters. These differences are reported and discussed.

SEMISYNTHETIC HOMOLOGUES OF THE ANTILEUKEMIC LIGNAN, STEGANACIN. R. P. Hicks and A. T. Sneden, Dept. of Chemistry, Va. Commonwealth Univ., Richmond, VA 23284.

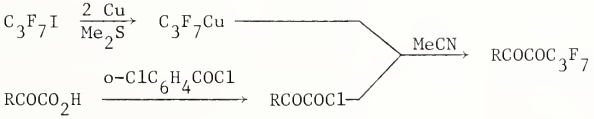
Steganacin is a bisbenzocyclooctadiene lignan lactone which has exhibited marginal antileukemic activity against the P388 lymphocytic leukemia in mice and potent cytotoxicity and antimitotic activity. Steganacin is similar to another lignan lactone, podophyllotoxin, in mode of action. In an effort to duplicate the improved antineoplastic activity that derivatives of podophyllotoxin have shown and to elucidate the structure-activity relationships among homologues of steganacin, a variety of C(5) derivatives of steganol, the parent C(5) alcohol of steganacin, have been prepared. Among the derivatives studied are a series of C(5) esters, C(5) ethers, and C(5) glucosides. The synthesis and antimitotic activity of these semisynthetic steganacin homologues will be discussed.

2-(1-NAPHTHYL)ETHYLTRIAMMONIUM METHYLSULFONATE AND RELATED COMPOUNDS. B.K. Holdaway, M.A. Pleva, M.E. Robson, J.K. Shillington*, S.W. Snyder (*Academy Member) Department of Chemistry, Washington & Lee University, Lexington, VA 24450.

We have attempted to extend the work of William Ashe, et.al., whose paper was presented here last year. Ashe began his syntheses with various aryl carbinols, such as 1-Naphthalene methanol and 9-Anthracene methanol, and produced the tributylammonium mesyl sulfonate salts. We attempted to run the same synthesis, using 1-Naphthalene ethanol as the starting material. Unable to synthesize the final tributylammonium salt, we did manage to make the sulfonate ester. We have also concentrated upon making the triethylammonium derivative, modifying the original Ashe synthesis to further favor Sn2 displacement. We believe we have succeeded in this attempt.

SYNTHESIS OF FLUORINATED α-DIKETONES. M. Hudlicky. Department of Chemistry, Virginia Polytechnic Institute and State University, Blacksburg, Va. 24061.

Perfluoroalkylcopper compounds the chemistry of which has been revived recently (W. T. Miller et al., p. O-27, Abstracts, the 9th International Symposium on Fluorine Chemistry, Avignon, France, Sept. 3-7, 1979) are eminently suited for syntheses of polyfluoro and perfluoro compounds. They are easily prepared and are more selective than fluorinated organometallics of lithium and magnesium. Their special feature is that they do not react with ketones but do react with acyl halides to form ketones. The reaction of perfluoroalkylcopper compounds with chlorides of α-keto acids provides the means for a one-step synthesis of fluorinated α-diketones. Reactions of perfluoropropylcopper with benzoylformyl chloride, trimethylpyruvyl chloride, heptafluoro-α-ketovaleryl chloride and oxalyl chloride will be discussed, and preparation of some fluorinated α-keto acids and their chlorides will be described.

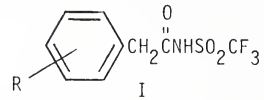


S-ADENOSYLMETHIONINE METABOLISM IN TISSUE CULTURE CELLS. Kathryn Mazina-Seaman and T. O. Sitz. Department of Chemical Sciences, Old Dominion University, Norfolk, VA 23508

A comparison of methylation level of RNA isolated from normal and cancer cells has shown the characteristic of hypomethylation in the neoplastic state. This has been correlated to an increased ratio of SAM/SAH (S-adenosylmethionine/S-adenosylhomocysteine) in tumor cells. These data suggest that SAH is not an inhibitor of methylation but that some other compound is inhibiting cellular methylation leading to an increase in the ratio of the substrate/product of the cellular transmethylation reactions. Such a compound could be one of the metabolic products of SAM such as dec SAM (decarboxylated SAM) and MTA (5'-methylthioadenasine) a precursor and product respectively of polyamine biosynthesis. We have developed a high-voltage electrophoresis procedure that allows us to resolve ^{35}S-labeled metabolic products of methionine. In this one demensional separation we can resolve SAM, SAH, dec SAM and MTA.

NEW DERIVATIVES OF TRIFLUROMETHANESULFONAMIDE AS ANTICONVULSANT AGENTS. Amy L. Manheim and James F. Wolfe, Department of Chemistry, VA Polytechnic Institute and State University, Blacksburg, VA 24061.

On the basis of earlier observations that various phenylacetylureas and sulfonamides possess significant anticonvulsant activity, a series of seven N-phenylacetyltrifluoromethanesulfonamides (I) were synthesized for anticonvulsant screening. All of these exhibited protection against Maximal

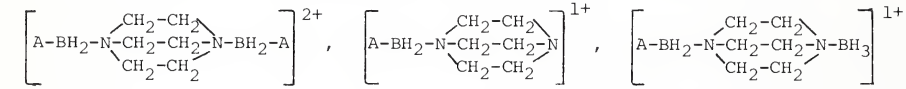


I

Electroshock (MES) induced seizures in mice at dosages of 30-100 mg/kg. The nature and position of substituent R had little influence on activity in this screen. The protection afforded against subcutaneous Metrazol (scMet) by these compounds decreased when the substituent R was changed from H to either electron donating or electron furnishing moieties. None of these compounds exhibited neurotoxicity below 300 mg/kg.

SYNTHESIS AND CHARACTERIZATION OF BIS-AMINE BORON CATIONS FROM 1,4-DIAZABICYCLO [2.2.2]OCTANE. Vernon R. Miller, Phillip E. Lockard*, and Mary E. Matuszko*. Dept. of Chemistry, Roanoke College, Salem, Va. 24153.

Various boron cations have been prepared using 1,4-diazabicyclo[2.2.2]octane as the focal point and other amines such as pyridine and trimethyl amine. Thus, it was possible to prepare dications in which an amineBH_2^+ was attached to both nitrogens of the diamine, monocations in which only one amineBH_2^+ was attached to the diamine, and monocation-boranes in which an amineBH_2^+ was attached to one of the nitrogen atoms and a BH_3 was attached to the other nitrogen of the diamine. Most of these cations could be prepared by allowing the diamine to react with an amineBH_2I and also by allowing an amine to react with the appropriate iodoborane of the diamine. They were isolated as the PF^- salts and characterized by ir and nmr. Their most unusual chemical property is the ease with which the diamine can be replaced by another amine.



where A= pyridine or trimethylamine

DETERMINATION OF ACTIVATION PARAMETERS OF BENZOQUINONE EPOXIDATION USING COMPUTER SIMULATION. E. W. Moomaw* and E. M. Hairfield. John Baker Daffin Lab. of Chemistry, Mary Baldwin Col., Staunton, VA 24401

Epoxides have been found to play a remarkable role in metabolism. It is generally accepted that metabolic hydroxylations of aromatic hydrocarbons proceed by way of intermediate epoxide formation. In this investigation, the kinetics of alkaline hydroperoxidation of benzoquinone is studied as a function of temperature. The epoxidation is monitored by nuclear magnetic resonance. A graph of percent products vs. time is plotted and compared to graphs simulated by a computer program developed specifically for this pseudo first order sequential reaction. From successful matching of the nmr data with the simulated data, the rate constants are determined. The rate constants at varying temperatures are then used to prepare Arrhenius plots, from which activation parameters are obtained. The significance of the activation parameters is discussed.

NORMAYTANCYPRINE, A NEW MAYTANSINOID FROM PUTTERLICKIA VERRUCOSA. A. T. Sneden, Depart. of Chemistry, Va. Commonwealth Univ., Richmond, Va. 23284.

Normaytancyprine, a new antileukemic maytansinoid, was isolated from Putterlickia verrucosa Szyszyl. (Celastraceae). Elucidation of the structure of normaytancyprine was accomplished by a combination of chemical and spectroscopic methods. The mass spectrum and ^1H NMR spectrum indicated that normaytancyprine was an 18-N-demethylmaytanside ester. Hydrolysis of normaytancyprine followed by preparation of the p-bromobenzyl ester of the side chain acid defined the structure of the side chain as an N-acyl derivative of N-methyl-ℓ-alanine. Finally, comparison of the ^{13}C NMR spectra of normaytancyprine with the spectra of other maytansinoids defined the structure of the N-acyl group. The isolation and structure elucidation of normaytancyprine, its antileukemic activity, and its relationship to other antileukemic ansa macrolides will be discussed.

ELECTRON SPIN RESONANCE STUDIES OF LITHIUM DITHIONITE. T. N. Robeson, R. L. Ake, and D. M. Oglesby. Dept. of Chem. Sciences, Old Dominion University, Norfolk, VA 23508

Lithium dithionite ($Li_2S_2O_4$) has been positively identified as the cathode discharge product of the lithium-sulfur dioxide cell by infrared spectroscopy and X-ray powder diffraction. In addition dithionite compounds are well suited to investigation by Electron Spin Resonance (ESR) spectroscopy since the dithionite anion is a dimer of the sulfur dioxide radical anion (SO_2^-).

ESR spectra of lithium dithionite samples synthesized at Old Dominion University were recorded from 90K to 575K. The room temperature spectra appeared to be a combination of two individual radical signals. At higher temperatures the signal sharpened considerably while maintaining its room temperature characteristics. Above 500K the spectrum irreversibly lost its characteristic shape. Below 210K the signal reversibly lost its characteristic shape. Also, at low temperature a half field signal was recorded. The origin of the signal was attributed to spin-spin coupling between neighboring radical species trapped in the crystal lattice.

Preliminary ESR investigations of cathode samples from lithium-sulfur dioxide cells produced spectra with significantly smaller linewidths than those of the pure $Li_2S_2O_4$.

THE CHEMISTRY OF URANIUM IN BOROSILICATE GLASSES. I: SIMPLE BASE COMPOSITIONS RELEVANT TO NUCLEAR WASTE IMMOBILIZATION. Henry D. Schreiber and G. Bryan Balazs*. Department of Chemistry, Virginia Military Institute, Lexington, VA 24450.

The basic chemistry of uranium has been investigated in some simple borosilicate glasses whose only multivalent element is uranium. The redox chemistry of uranium in these glass-forming melts can be described by the U(VI)-U(V)-U(IV) equilibria which are quite dependent on the melt temperature and imposed oxygen fugacity. The conditions necessary to stabilize U(III) in the glasses were also determined. The assigned coordination sites of U(VI) as the uranyl ion, U(V) in six-fold coordination with slight tetragonal distortion, U(IV) in eight-fold coordination, and U(III) in six-fold coordination in borosilicate glasses were inferred from visible-near infrared spectroscopy. The solubility of uranium in a typical borosilicate was dependent on the U(IV) concentration with U(IV) saturation at 1150°C as about 9 wt% before UO_2 precipitated. The information collected in this study sets a basis for the chemistry of uranium in glasses relevant to nuclear waste immobilization.

A SCIENTIFIC INSTRUMENTATION INFORMATION NETWORK, Frank A. Settle, Jr., VMI, Michael A. Pleva, W&L, Harold McNair, VPI&SU, Frank Karasek, Waterloo Univ.

The Scientific Instrumentation Information Network will be described. This network consists of a computer-based information system for users of selected methods of chemical analysis. The information is currently disseminated from a central computer at VMI to user's terminals via commercial telephone lines. Future plans include the storage of information on floppy disks for access with popular microcomputer systems.

Instrument modules currently available on the system are Gas Chromatography and GC/MS. Each module consists of a series of files. The file materials are written by members of the module task force under the direction of their leader. Prof. Harold McNair of VPI&SU, Blacksburg, VA, heads the GC task force, and Prof. F. W. Karasek, Waterloo University, Waterloo, Ontario, heads the GC/MS group. Mr. Ted Rains of NBS, Washington, DC, is currently directing a group working on atomic absorption spectroscopy.

The strengths and weaknesses of the system will be presented based on access by several hundred users during the initial year of operation.

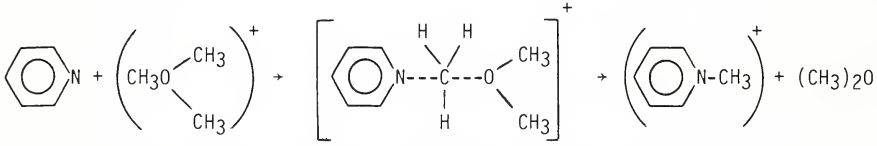
*This work is supported by NSF Grant SED 79-19780.

THE SEQUENCE OF AN ELONGATED FORM OF 5.8S RIBOSOMAL RNA. T. O. Sitz, D. Smith. Department of Chemical Sciences, Old Dominion University, Norfolk, VA 23508

The 5.8S rRNA is found in eucaryotic cells hydrogen bonded to the 28S rRNA in the large ribosomal subunit. Position 14 in the sequence contains a partial 2'-O-methylated uridine which was found to vary from 0.10 to 0.85 molar yields in a variety of tissues with the lowest modification found in cancer cells. When 5.8S rRNA from whole cell RNA preparations was separated on high resolution polyacrylamide slab gels multiple bands of 5.8S rRNA were observed, three major bands followed by three less intense minor bands. The three major bands comigrated when applied to denaturing gels (7M urea). Oligonucleotide mapping demonstrated that the fastest migrating band was not ribosemethylated at position 14 in the sequence suggesting that methylation prohibits the most compact isomer from forming. The three faint bands also formed a single band on 7M urea polyacrylamide gels, but migrated slower than the major band. Sequence analysis and the kinetics of formation show that this minor form of 5.8S rRNA is elongated at the 5' end and appears to result from aberrant processing. The sequence of the minor form is p(C)CGAUACG-which is five or six nucleotides longer than the major form and has a heterogenous termini. (NIH grants CA-23632 and CA 28513).

CALCULATION OF AN ENERGY SURFACE FOR THE METHYLATION OF PYRIDINE. M. D. Stovall*, J. C. Schug and J. W. Viers, Dept. of Chemistry, V.P.I. & S.U., Blacksburg, Va.

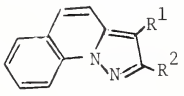
Semi-empirical MNDO-SCF molecular-orbital calculations have been used to generate a potential energy surface for the reaction of trimethyloxonium ion with pyridine.

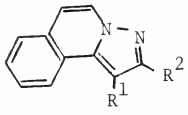


Present calculations were limited to geometries in which the NC and CO bonds were colinear. The surface exhibited well-defined entrance and exit valleys separated by a transition state. Barrier heights were approximately 23 kcal $mole^{-1}$ for the forward reaction and 55 kcal $mole^{-1}$ for the reverse reaction. The energy surface was successfully fitted to an empirical expression which included Morse functions for the NC and CO bonds. Extension to substituted pyridines is presently in progress to examine the effects of steric hindrance.

CYCLOADDITION REACTIONS OF N-p-TOLUENESULFONYLIMINO DERIVATIVES OF QUINOLINE AND ISOQUINOLINE. A ROUTE TO PYRAZOLO[1,5-a]QUINOLINES AND PYRAZOLO[5,1-a]ISOQUINOLINES. R.J. Sundberg and J.E. Ellis, Dept. of Chemistry, Univ. of Virginia, Charlottesville, Va. 22901

N-p-Tolunesulfonylimino ylides of quinoline and isoquinoline give cycloadducts with electrophilic acetylenes. The adducts are spontaneously aromatized under the conditions of their formation by elimination of p-toluenesulfinic acid to give pyrazolo[1,5-a]quinolines and pyrazolo[5,1-a]isoquinolines, respectively. The regiospecficity of the cycloaddition is the same as for N-amino ylides for these acetylenic esters. The adducts from p-nitrophenylacetylene are formed by addition of the imino nitrogen to the unsubstituted acetylenic carbon. This orientation and the unreactivity of phenylacetylene under comparable conditions, indicate that the cycloaddition is controlled by dipole HOMO-dipolarophile LUMO interactions.

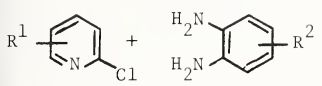




R^1	R^2
CO_2CH_3	CO_2CH_3
CO_2CH_3	H
CO_2CH_3	CH_3
$CO_2C_2H_5$	phenyl
NO_2-phenyl	H

SYNTHESIS OF PYRIDO[1,2-a]BENZIMIDAZOLES BY CYCLIZATIVE CONDENSATION OF 2-HALOPYRIDINES AND 1,2-BENZENEDIAMINES. SCOPE AND MECHANISM OF THE REACTION. R.J. Sundberg and J.E. Ellis, Dept. of Chem. Univ. of Virginia, Charlottesville, Va. 22901

The scope and mechanism of acid-catalyzed cyclizative condensation of 2-halopyridines with 1,2-benzenediamines has been explored. The reaction requires a 2-halopyridine which is activated toward nucleophilic substitution. Evidence in favor of a mechanism involving pyridine ring opening is presented. Of three substituted 1,2-benzenediamines which were examined, the 4-nitro compound gave a single cyclization product whereas 4-chloro and 4-methyl derivatives gave isomeric mixtures. The structure of the product from 2-chloro-5-nitropyridine and 4-nitro-1,2-benzenediamine is shown to be 2,8-dinitropyrido[1,2-a]benzimidazole.



R^1	R^2
2-NO_2	H
2-NO_2	8-NO_2
2-NO_2	7,8-Cl[a]
2-NO_2	7,8-CH_3[a]
4-NO_2	8-NO_2

a) Mixture of isomers

PHYSIOCOCHEMICAL CHARACTERIZATION OF SOME ANTITUMOR ACTIVE POLYMERS. Ryozo Takatsuka and Raphael M. Ottenbrite. Department of Chemistry, Virginia Commonwealth University, Richmond, Virginia 23284.

The physicochemcial properties of antitumor active polymers were studied by means of viscometry, potentiometry and UV spectroscopy. Poly(maleic anhydride-co-acrylic acid); PMAAA, poly(maleic anhydride-co-methacrylic acid); PMAMAA and poly(itaconic acid-co-styrene); PItSt were prepared by conventional copolymerization methods and separated into defined molecular weight fractions by ultrafiltration before evaluation. The composition ratio of the PMAAA was 0.22 MA to 0.78 AA, that of PMAMAA was 0.49 MA to 0.51 MAA and that of PItSt was 0.47 It to 0.53 St. The potentiometric titration curve of PItSt showed a clear infection at half the neutralization point. This observation can be explained in terms of the hydrophobic interaction and the different properties of the two carboxyl groups on the It moiety. The inflection of the potentiometric titration curve of PMAMAA occurred in the vicinity of one third the neutralization point. It seems that the conformational change of PMAMAA by the electrostatic repulsion between the ionized groups is assisted by a hydrophobic interaction of methyl group on the MAA moiety. The inflection of the potentiometric titration curve of PMAAA occurred above 80% of the neutralization point. This indicates that one of the carboxyl groups on MA moiety may be difficult to ionize because of the nearest neighboring group effect and no assistance of a hydrophobic group. The present observations are important in developing an understanding of the relationship between the structure of these polymers and their physiological activity. The authors wish to acknowledge the NIH support by grant AI-15612.

CHEMICAL STUDIES OF OXOMOLYBDENUM(VI) COMPLEXES WITH TRIDENTATE SCHIFF BASE LIGANDS CONTAINING O, N AND S DONOR ATOMS. Joseph Topich and James T. Lyon III, Department of Chemistry, Virginia Commonwealth Univ., Richmond, Virginia 23284.

We have recently been investigating the chemistry of cis-dioxomolybdenum(VI) coordination complexes as a function of ligand structure. In previous work tridentate Schiff base ligands incorporating the ONO donor atom set were employed. With this series the cathodic reduction potentials are controlled by subtle ligand modifications. Our present work involves the preparation of Schiff base ligands incorporating the ONS donor atom set. These ligands were synthesized using 5-X-salicylaldehyde (X = CH_3O, H, Cl, Br) and 2-aminothiophenol or 2-aminoethanethiol. The cis-dioxomolybdenum(VI) complexes were prepared by reacting the Schiff base ligands with $MoO_2(acac)_2$ (acac = acetylacetonate anion) or MoO_2Cl_2 in ethanol. Cyclic voltammetry was used to determine cathodic reduction potentials. Trends in cathodic reduction potentials and energies of electronic transitions will be discussed in terms of ligand substituent and ligand structural effects. Comparisons will also be made between cis-dioxomolybdenum(VI) complexes which are coordinated by the ONO or ONS donor atom set.

THE PREPARATION AND CHARACTERIZATIONS OF LOW MOLECULAR WEIGHT MALEIC ANHYDRIDE VINYL ACETATE COPOLYMERS. James Threadgill and Raphael M. Ottenbrite*. Dept. of Chemistry, Virginia Commonwealth University, Richmond, VA 23284.

It has been found that the low molecular weight polyanions such as maleic anhydride divinyl ether copolymers have significant antitumor activity. This activity is related to the ability of these polymers to activate macrophage to exhibit cytotoxic behavior. Consequently, we have prepared and evaluated low molecular weight fractions of maleic anhydride - vinyl acetate for macrophage activation evaluation. Our initial efforts were directed to finding conditions of polymerization that would afford larger yields of low molecular weight polymer. These were then fractionated into molecular weight ranges of 1,000 - 10,000 and 10,000 - 30,000. Biological activity was determined for both of these fractions as well as for the analog of these fractions after complete and partial hydrolysis of the acetate group. An evaluation of the H^1 and C^{13} NMR of these polymers will be discussed.

DEVELOPMENT OF NEW LANTHANIDE CHELATES AS FLUORESCENT STAINS FOR CYTOLOGY. Lidia M. Vallarino, Mauro Bassetti*, and Neda Gent, Department of Chemistry, Virginia Commonwealth University, Richmond, VA 23284.

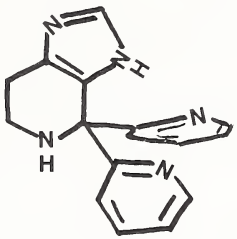
The objective of our research is to develop new fluorescent stains suitable for the multiple labeling of cytological specimens. The key features of our stains are a strong fluorescence with nearly monochromatic emission, and a high thermodynamic stability in aqueous solution. We have previously established that the most favorable fluorescence intensity and lifetime may be achieved using the Europium(III) and Terbium(III) ions as the light-emitting centers, and the mononegative anions of β-diketones as the light-absorbing, chelating ligands. However, when these strongly fluorescent complexes were coupled to proteins, the fluorescence rapidly decreased in intensity owing to dissociation of the complexes. To improve the stability of the complexes while retaining the structural features favorable to monochromatic light emission, we undertook the synthesis of two series of bis(β-diketones), I and II, capable of functioning as tetradentate dinegative ligands toward the lanthanide(III) ions.
I) $CH_3COCH_2CO(CH_2)_nCOCH_3COCH_3$ n=6,8,10 II) $(CH_3CO)_2CH(CH_2)_nCH(COCH_3)_2$ n=8,10,12
The keto-enol tautomerism and acid ionization constants of these ligands have been investigated and correlated with the trends observed for the fluorescence intensity of their Eu(III) and Tb(III) complexes.

AN IMPROVED SYNTHESIS OF ARYLSULFONES.
S. B. White,* F. G. Varboncoeur,*& H. J. Sipe, Jr., Department of Chemistry, Hampden-Sydney College, Hampden-Sydney, VA. 23943

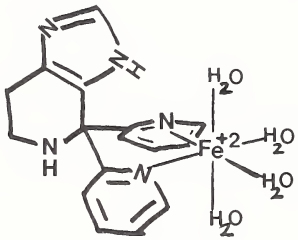
We report a modification of the synthesis of arylsulfones that has been previously reported by Graybill [J.Org.Chem.,1967,32,2931]. That synthetic procedure uses polyphosphoric acid (PPA) as a dehydrating solvent for the appropriate sulfonic acid and aromatic hydrocarbon. The reaction is thus analogous to the Friedel-Crafts procedure in which care must be taken to achieve anhydrous conditions. By this procedure, Graybill produced 4,4'-ditolylsulfone in 47% yield. Our modified procedure, which results in substantially improved yields, subjects the solvent (PPA) and the reagents to drying in situ by adding P_2O_5 to them prior to mixing them for the reaction to proceed. By this modified procedure we produced 4,4'-ditolylsulfone in 89% yield. Similarly, a previously unreported compound, bis-(p-t.butylphenyl)sulfone was prepared in 80% yield. Characterization data for these two compounds confirm the successful syntheses.

SYNTHESIS AND BIOLOGICAL EVALUATION OF THE 4,5,6,7-TETRAHYDROIMIDAZO (4,5-C) RING SYSTEM. R. L. Williams and Sandra Neergaard. Department of Chemical Sciences, Old Dominion University, Norfolk, VA 23508

Histamine when condensed with 2,2-dipyridylketone gives rise to a rather unique tetrahydroimidazo (4,5-C) pyridine ring system (1). This compound and its iron complex (2) have been synthesized and found to be relatively potent neuromuscular blocking agents. Further investigations have shown it to be a depolarizing, nicotinic blocker similar in activity to decamethonium. The methods of synthesis, identification and biological evaluation will be discussed.



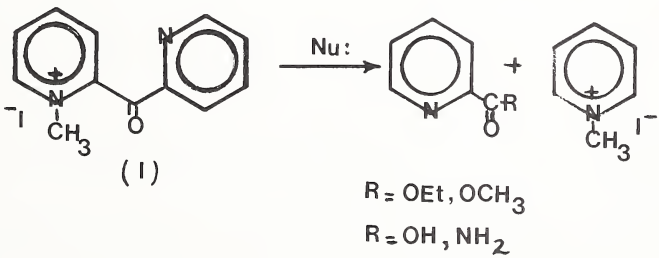
(1)



(2)

SOLVOLYSIS OF DI-2-PYRIDYLKETONE METHIODIDE. R. L. Williams and Sandra Neergaard. Department of Chemical Sciences, Old Dominion University, Norfolk, VA 23508

The reaction of di-2-pyridylketone methiodide (1) with various nucleophiles such as alcohols, hydroxide ion and ammonia give rise unexpectedly to nucleophilic substitution at the carbonyl carbon and subsequent cleavage of the dipyridyl ring system. The conditions associated with this interesting substitution reaction together with the scope and possible mechanistic implications will be discussed.



(I)

Education Section

SUCCESS IN BIOLOGY: WHAT ARE THE CONTRIBUTING FACTORS? H. S. Adams and A. M. Dutrow. Dabney S. Lancaster Community College, Clifton Forge, VA 24422.

Relationship of several variables to mean examination grade achieved in college biology was studied. Subjects were 111 students enrolled in General Biology I at Dabney S. Lancaster Community College selected randomly from students who took the course over a six-year period (1976-1981).

Significant Pearson-product moment correlation coefficients (.01 alpha level) were found between college biology grade and CGP math score, CGP reading score, and HS biology grade, in descending order. Stepwise multiple regression produced a prediction equation (r^2=.3190) as follows: College Biology Grade = .2614 (HS Biology Grade) + .3980 (CGP Math Score) + .4801 (CGP Reading Score) + 3.1724.

Students with two or more years of HS algebra scored significantly higher in college biology than students with less algebra. This was attributed to a presumably better high school background in general.

THE TEACHING AQUARIUM: EXPLORING SCIENCE CONCEPTS IN THE UNDERWATER WORLD. R. Wesley Batten and Vicki Price*, Math. & Science Ctr., Richmond, VA 23223

The Mathematics and Science Center's teaching aquarium is dedicated to introducing and enriching aquatic education in area schools. The Atlantic Ocean, the Chesapeake Bay, a tidal river, a freshwater lake and a mountain stream are represented by five large aquariums ranging in capacity from 480 to 3600 gallons. A coral reef aquarium displays animals which provide living illustrations of specialized animal adaptations and behaviors. The tide pool and fossil pit exhibits allow students to study fossils and live marine animals by using their sense of touch as well as sight.

The aquarium lesson teaches several basic science concepts, including the importance of water to life, the interaction of living and nonliving things, how living things are classified, how organisms are adapted to their environment and how human use affects our water resources. The lesson encourages students to use process skills such as observation, classification, and communication.

The goal of the aquarium is not only to teach science concepts but also to develop positive attitudes toward the conservation of our water resources and to encourage further investigation of the water environment.

WERE THEY WATER WISE-GUYS (OR GALS)?: THE EFFECTS OF WATER CONSERVATION INSTRUCTION ON 7TH GRADERS. Sandra K. Birch* Virginia Water Resources Research Center, 617 N. Main St., Blacksburg, Va. 24060

The purpose of the study was to evaluate the short-term effectiveness of a specific water conservation instructional unit in increasing students' knowledge of water conservation practices and influencing the students' attitudes toward efficient water use. An author-developed instrument was administered to 843 seventh grade Life Science students within a Solomon 4-Group experimental design. The research instrument consisted of 1) 30 multiple-choice questions to ascertain the factual and conceptual base of the students and 2) 25 statements which measured the students' attitudes toward water and water conservation on a Likert-type scale.

The analyses of data invcelved looking at all combinations of treatment and non-treatment group scores for each of the two instrument sections. Results of the study revealed that students in the treatment groups scored significantly higher ($p < .0001$) on both the knowledge and attitude post-tests than the non-treatment groups. Gain scores for both sections of the test were also significantly greater ($p < .0001$) for the treatment group. Further, a significant positive correlation ($p < .0001$) was noted between knowledge and attitude mean post-test scores of the treatment groups.

FISHING FOR INFORMATION? RESOURCES FOR MARINE EDUCATION. Sue Gammisch and Lee Lawrence. Marine Advisory Specialists, Va. Sea Grant at VIMS, Col. of William & Mary, Gloucester Point, Va. 23062.

Virginia's Sea Grant Program provides services to the Commonwealth in the areas of marine research, advisory services and education. Educational efforts include graduate studies, professional and technical information and instruction, continuing education, K-12 formal and informal education, publications and information dissemination.

This session introduced participants to the marine education resources now available to educators through the Virginia Institute of Marine Science Sea Grant Marine Education Center. Our recently produced slide tape presentation was used to explain the raionale of marine education and to introduce the National Marine Education Materials System (MEMS). The system is computerized for rapid access to a wide range of marine education documents pertinent to various disciplines and grade levels. Session participants had the opportunity to select a topic for a customized bibliography, and to learn how to find marine education materials appropriate for specific educational needs.

Teachers, students and administrators are cordially invited and encouraged to make use of the variety of marine education materials available through Virginia Sea Grant.

EXTENDING THE MARINE SCIENCE CENTER. Charles Hughes*, and Jeane J. Dughi, Dept. of Instruction, Norfolk Public Schools, P. O. Box 1357, Norfolk, VA 23510.

Changing the Elementary Science Center into a center for K-12 marine science education was the first move toward extending the center to service a wider range of participants. Presentations made to PTA's, the Elementary Principals Association, elementary and secondary inservice teachers, and gifted and talented classes; innovative programs developed for special education classes, including PPDD, EMR, LD AND ED; and field trip activities extended the Center's activities beyond the scope of the previous program. As part of the regular classroom instruction within each school, a videotape has been prepared to accompany the pre and post visit lesson kit designed for each grade, K-6. Plans are being developed to enlarge the space of the center to more comfortably handle the larger number of visitors, which has doubled in one year to almost 9,000 students and teachers.

4-H PROJECTS CAN SUPPLEMENT THE PUBLIC SCHOOL SCIENCE CURRICULUM. Joyce H. Jones. Dept. of Poultry Science, VPI&SU, Blacksburg, V. 24061

The integration and delivery of Va. Cooperative Extension youth programs (4-H) with the secondary school science curricula offers teachers unique program areas to compliment many existing science units. Va. Cooperative Extension 4-H science resources provide imaginative and innovative programs to stimulate youth interest and learning. Most 4-H program areas are geared to the life sciences or science units for the 7th, 8th, or 9th grades. Program areas include plant and animal sciences, physical sciences (energy, electric) and environmental science. Local Va. Cooperative Extension County or City Agents serve as resource persons for the teachers to contact.

Overall teacher reception and use of 4-H materials in the classroom can be evidenced by a 1981 enrollment of 18,006 Virginia youth in the 4-H Embryology project. Resources include teacher training and textbooks, incubators, fertile eggs, student workbooks, audiovisual materials and preserved embryonic specimens. Teacher evaluations of the project emphasize benefits of the 4-H project as 1) high student interest and motivation; 2) improved observation skills and retention of knowledge gained; 3) stimulating an enthusiasm for and awareness of science.

ENVIRONMENTAL EDUCATION IN VIRGINIA: RESULTS OF A TEACHER SURVEY. Alvin M. Pettus. Div. of Curriculum and Instruction, VPI & SU, Blacksburg, Va. 24061

A sample of Virginia public school teachers were surveyed by questionnaire to assess the status and progress of environmental education (EE) in the schools. Responses indicated that most schools did not have a planned EE program and most teachers had not made EE a part of the content of the courses they taught. Where EE programs existed emphasis was thought to be on environmental awareness and man's relationship to his environment. In their courses, teachers emphasized energy and pollution problems more than they did other EE topics. Most respondents identified curriculum guides, other instructional materials and resources as the most important needs for developing or advancing EE. It was concluded that EE was not among the areas given priority in Virginia schools and that very little progress was being made toward making a comprehensive program of EE available to each student.

MARINE EDUCATION AND ITS APPROPRIATE UTILIZATION IN THE INSTRUCTION OF GIFTED STUDENTS. Mary Sparrow, Marine Advisory Specialist, VA Sea Grant at VIMS, Col. of William & Mary Gloucester Point, Va. 23062. Alice Wakefield, Coordinator Gifted and Talented Program, Gloucester County Schools, Gloucester, Va. 23061.

PROJECT CREST, a marine environmental studies program for gifted students in the Gloucester County School System, was initiated by School officials and funded by the Department of Education, Commonweatlh of Virginia in 1978 as a pilot study. The goal of the project was to provide opportunities for creative and intellectual exploration and to develop a marine science curriculum appropriate for elementary academically gifted students.

The development of this curriculum and the implementation of its instruction was coordinated by the Virginia Institute of Marine Science-Sea Grant Marine Education Staff. Marine science was selected because of the maritime heritage of the community and aquatic nature of Gloucester's environment, and because the philosophy of gifted education and that of marine education blend well together. Both emphasize higher level thinking skills and experiential activities.

This presentation looked at Project Crest from two perspectives - the development and coordination of a gifted program and the development of a marine science curriculum differentiated for gifted students in grade 2-6.

WALL TO WALL BLACKBOARDS. H. W. Straley. Dept. of Math, Woodberry Forest Sch., Woodberry Forest, Va. 22989

Mathematics is a participant sport not a spectator sport and the mathematics classroom should be designed with this premise in mind. Teaching techniques designed to increase the effective use of class time and to stimulate student participation in learning activities should be the goal of every teacher. The purpose of this presentation was to describe such a set of teaching techniques.

The procedures described require blackboard space for about 15 students. Unfortunately most classrooms are not equipped with this much blackboard space. However, schools do have portable blackboards and additional boards can be added at minimal cost.

These techniques were originally conceived at the U.S. Military Academy and have been further developed by teachers at Woodberry Forest School (Virginia) and Newington College (Sydney, Australia). This presentation consisted of a videotape of actual classes using the blackboard techniques followed by discussion of their applicability to conventional classrooms.

Engineering Section

V.P.I. TURBOMACHINERY AND ROCKET PROPULSION RESEARCH AND FACILITIES. W. T. Cousins,* Dept. of Mechanical Engineering, Va. Polytechnic Inst. and State University, Blacksburg, VA 24060. Special facilities have been developed for use in propulsion-related research in the Mechanical Engineering Dept. at VPI&SU. Unique measurement techniques have been developed to support ongoing research in turbomachinery and rocket propulsion.

One of the several areas in turbomachinery being studied is that of axial-flow compressors as related to jet engine technology. The main emphasis is the study of the stability and unsteady pressure response of the machine which is critical to proper operation. Through the use of radio-telemetry, techniques have been developed to monitor pressure fluctuations internal to the rotating components of the compressor while in operation. Recently, work has begun in sensing the unsteady pressure response due to internal flow disturbances and their effect on turbomachinery noise. Facilities include both high-speed and low-speed compressors. The high-speed laboratory houses a General Electric T-64 turboshaft engine as a drive for the compressor rig.

In rocket research, studies of solid-propellant burning are being performed. Erosive burning of the solid propellant is a common problem during rocket operation. The goal of this project is to build and test a non-intrusive device (utilizing microwave reflections) for monitoring the burning surface of the propellant and to research erosive burning laws to permit design of solid propellant rocket motors.

SURFACE ROUGHNESS FEATURES OF ACCRETING ICES. R.D. Kirchner. Inst. for Hypersonic Studies, 7602 Cornwall Road, Richmond, Va. 23229.

Icing on airfoil leading edges leads to significant changes in the lift and drag characteristics that can be attributed to the roughness of the ice itself. The increase in skin friction drag can be directly related to the location of transition, and Achenback's studies were used to establish the relationship between the icing surface roughness and the location of transition on circular cylinders. A numerical simulation of leading edge icing was used to establish a model of icing roughness as a function of the free stream velocity, temperature, and liquid water content; and Prandtl's hypothesis for turbulent shearing stress was used to develop a corresponding theoretical model. The Reynolds analogy was used to relate skin friction and heat transfer terms, and an empirical model, based on Schlichting's studies of surface roughness elements, was used to express the icing texture in terms of its equivalent sand roughness. The resulting models were found to be comparable exponential functions, but their use of several empirical parameters precluded further comparisons and suggested the need for further experimental studies.

A SPECIAL PRUPOSE 92 POLE GENERATOR. Howard R. Johnson, The Permanent Magnet Research Institute. In our development of a 92 pole permanent magnet generator, a magnetizer was developed to magnetize the 92 alternate magnetic poles on the rotor.

The magnetizer developed worked most effectively and demonstrated quite clearly our concept of what constituted the magnetic lines of force.

We had postulated that the magnetic line of force is simply a positive particle in orbit at right angles around a spinning or flowing electron. We believe that Fleming's right hand rule and other similar rules are simply efforts to explain this kind of phenomena.

What we found, that was not so evident, is the existence of a counter rotating particle of the same charge.

The results of these effects was a magnetizer that used a single current in one direction to magnetize both North and South poles. In fact, it became evident that the only difference in a North and South pole was the direction of travel of the positive particles that determined the poles.

NUMERICAL CALCULATION OF CONFIGURATION FACTORS FOR TWO-DIMENSIONAL RADIANT HEAT EXCHANGE. R. Daniel Pace,* and J. T. Beard, School of Engineering and Applied Sciences, University of Va., Charlottesville, VA 22901. A numerical integration scheme is proposed which will accurately and quickly determine configuration factors for all sides of a two-dimensional enclosure. The concept is based on the discrete transfer method introduced by F. C. Lockwood and N. G. Shah in their paper presented to the Eighteenth Symposium (International) on Combustion.

Any arbitrary enclosure which may include walls which interfere with the view field of other walls can be handled.

The computer code which implements this method is currently being developed and has so far met with limited success.

CONTROLLED VENTILATION FOR DESTRUCTION OF INSECTS IN AGRICULTURAL WAREHOUSES. J. T. Beard, F. A. Iachetta, J. H. Arthur,* School of Engineering and Applied Sciences, Univ. of Va., Charlottesville, VA 22901, D. P. Childs* and L. W. Fletcher,* Stored Tobacco Insects Lab., A.R.S. USDA, P.O. Box 10125, Richmond, Va 23240. Cooperative research by the University of Va. and the U. S. Department of Agriculture is investigating controlled ambient air ventilation cooling as a concept for obtaining temperatures low enough to cause destruction of insects in stored agricultural products. Studies include analytical simulation of the response of the warehouse environment to ambient environment and the changes in that response which occur when controlled ambient air ventilation is provided. The influence of building design parameter variations on the thermal response will be determined through use of computer studies.

Experimental measurements were obtained during the winter of 1981-82 for thermal response of two similar warehouses, one being a reference building and the other being modified with temperature controlled fans which provide ventilation cooling during appropriate periods of time. Experimental results will be used to verify the validity of the computer simulation. The verification phase of the research is approximately completed, and the influence of building design parameters will be evaluated in the near future.

VIRGINIA'S WATER SUPPLY PROBLEMS AND MANAGEMENT OPTIONS. W. E. Cox. Dept. of Civil Engineering, Va. Polytechnic Inst. and State Univ., Blacksburg, Va. 24061

Recent droughts have emphasized water supply problems confronting some of Virginia's urban areas. Yet an assessment of available water supply in relation to existing and projected demand indicates that many areas of the state will continue to experience conditions of water abundance, even during periods of moderate drought. Such an assessment shows the state's major water problem to consist of the inability of a few areas to meet water demand from strictly local sources. A potential solution to such shortages consists of the transfer of water into areas of deficit from areas of water abundance. However, present institutional arrangements do not provide a basis for objective evaluation of the merits of proposed transfers, suggesting a need to consider institutional modification. The relative scarcity of likely water-use conflicts in Virginia suggests that statewide administrative control of water use is an excessive reaction to the problem. A more appropriate response would be the creation of a special board to evaluate proposed water transfers and approve those transfers in the best interests of all the citizens of the state under conditions necessary for protection of the water's area of origin. Such an institutional change has potential to produce a net benefit to the citizens of the Commonwealth.

Environmental Science Section

RELATIONSHIPS BETWEEN TREE RINGS, Larix larch, ATLANTIC MACEREL LANDINGS, Scomber scomberus AND SEA SURFACE TEMPERATURES. Herbert M. Austin*, Virginia Institute of Marine Science, College of William and Mary, Gloucester Point, VA 23062.

Summer landings of Atlantic mackerel (Scomber scomberus) in Gloucester, Mass. during 1860-1872 show a statistical relationship to the temperature induced variations in the tree ring growth in the Canadian larch (Larix larch). Landings were reduced (55-85 thousand barrels) during warmer years, but increased during those years where temperatures were normal or below normal (128-142 thousand barrels). Tree rings correlate well with summer temperatures. It is suggested that in warmer years the mackerel migrate further north and so are not available to the inshore fishery for as long as they are in normal or cooler years.

DETECTION OF INFRASOUND GENERATED BY CLEAR AIR TURBULENCE. F. BADAVI, A.J. ZUCKERWAR.* Dept. of Physics, Old Dominion Univ., Norfolk, Va. 23508

A multichannel, acoustic AM carrier system has been developed for a wide variety of applications, particularly for air-craft noise and sonic-boom measurements. Each data acquisition channel consists of a condenser microphone, an acoustic signal converter, and a Zero Drive Amplifier, along with peripheral supporting equipment. At present the system is used to collect infrasonic data in conjunction with clear air turbulence study. Finally the physical properties and design objectives which influenced the design of the measurement system for infrasonic are catagorically summarized, and the techniques and instrumentation used for measurement are described. (Supported by NASA Grant NAG-I-142 & 234.

IMPACT OF HEAVY METALS ON AQUATIC ORGANISMS FOLLOWING A TOXIC SPILL. S. J. Barker*, and R. C. Hoehn*. Dept. of Civil Engr., VPI&SU, Blacksburg, VA 24061

A wood preserving waste spill into a small stream occurred near Culpeper, Virginia during January, 1981. The spill contained the heavy metals copper, arsenic, and chromium. A nearby chemical waste landfill is a potential site of contamination as well. Aquatic insects, crayfish, detritus and small fish were qualitatively sampled at sites along the affected watercourses. Species diversity, community structure and community function were examined in order to determine the effects of the spill and landfill on aquatic insects. Heavy metal levels in aquatic insects, crayfish, detritus and small fish were determined and a pathway of the metal ions through the aquatic food web was considered.

VENTILATORY RESPONSE OF BLUEGILL SUNFISH (Lepomis macrochirus) TO EXPOSURE TO COPPER, AMMONIA AND SODIUM LAURYL SULFATE. Douglas M. Bloem and Arthur L. Buikema, Jr. University Center for Environmental Studies and Dept. of Biology, Virginia Polytechnic Institute, Blacksburg, Virginia 24061.

A test apparatus utilizing a minicomputer-interfaced system analyzed the rate and amplitude of the electrical ventilatory muscular potentials detected by non-contact wire electrodes. Fish were exposed to the three toxicants at doses of 100%, 50% and 20% of the incipient LC50 determined by 10-day flow-through bioassays.

Changes in rate and amplitude of each fish's ventilatory signal, upon exposure to a toxicant, were calculated. Analyses of variance performed separately on the data for each toxicant showed significant differences in response to different doses for all toxicants tested. By Duncan's multiple range test, minimum concentrations of each toxicant giving changes in rate or amplitude greater than that of controls were: 0.2 mg/l for copper, 0.3 mg/l for ammonia (unionized) and 1.1 mg/l for SLS. No significant differences between 2-hr and 4-hr exposures were found, but an apparent trend toward increased response with longer exposure time was noted. All toxicants investigated caused changes in both rate and amplitude of the fishes' ventilatory signal. A strong correlation was found between aincreses in ventilatory rate and decreases in signal amplitude.

ENVIROMENTAL INFLUENCES ON THE MIGRATORY BEHAVIOR OF CHINOOK SALMON (ONCORHYNCHUS TSHAWYTSCHA) IN THE LOWER YUKON, ALASKA. J. E. Clark, P. R. Mundy*, Dept. of Oceanography, Old Dominion Univ., Norfolk, Va. 23508

A quantitative description of the migratory timing of chinook salmon (Oncorhynchus tshawytscha) as a function of tidal stage and wind speed is under development to aid fisheries management for the Alaska Department of Fish and Game (ADF&G). The ADF&G has operated a test fishery concomitant to the commercial fishery on the Lower Yukon River since 1963. Intraseason fluctuations in the time distribution of abundance indicate the possibility of two or more temporally distinct stocks or races of chinook salmon in the fishery. The environmental factors of winds and tides further modify the migratory timing, resulting in several peaks of abundance. The ability to predict the occurrence of the peaks of abundance in time is the primary objective of the research.

PARTICULATE AND GASEOUS ATMOSPHERIC HYDROCARBON CONCENTRATIONS IN AN URBAN ENVIRONMENT. Charles T. Farmer* and Terry L. Wade, Dept. of Oceanography, Old Dominion University, Norfolk, VA 23508.

Atmospheric particulate and gaseous hydrocarbon samples were collected at Old Dominion University, Norfolk, VA between July 29 and November 2, 1981. The samples were collected using a high volume vacuum pump that pulled air through a Gelman A/E glass fiber filter and 2 to 3 polyurethane foam plugs. Hydrocarbons retained by the filter, which traps particles larger than 0.3μm were defined as particulate, while hydrocarbons passing through the filter but retained by the foam plugs were defined as gaseous. Gaseous hydrocarbon concentrations ranged from 2.9μg/m^3 to 5.1μg/m^3 and particulate hydrocarbon concentrations ranged from less than 0.02μg/m^3 to 1.8μg/m^3. Sample volumes ranged from 44m^3 to 660m^3 with sample collection times ranging from 4 to 12 hours. Anthropogenic hydrocarbons were detected in both the particulate and gaseous phases, however gaseous hydrocarbons usually have a higher concentration. Samples were also found to contain biogenic N-Alkanes and anthropogenic polycyclic aromatic hydrocarbons (PAH) some of which are known carcinogens. The sampling technique used has been found to be analogous to a chromotographic column, with higher molecular weight hydrocarbons being retained on the Gelman A/E filter and progressively lower molecular weight hydrocarbons being retained on consecutive plugs. The effects the observed hydrocarbon speciation may have on atmospheric hydrocarbon distribution and deposition are discussed.

DEVELOPMENT OF A SOLAR ENERGY MEASUREMENT LABORATORY FOR THE STUDY OF INSOLATION VARIATIONS AT HAMPTON, VIRGINIA. T. J. Griffin*, D. A. Whitney, and D. D. Venable. Dept. of Physics and Engineering Studies, Hampton Institute, Hampton, Virginia 23668.

The purpose of this three-year study is to investigate the cloud dependence of incident solar radiation at Hampton, Virginia. Solar irradiance at the Earth's surface is related to the extraterrestrial solar irradiance, to radiation absorbed and emitted by the atmosphere and clouds, and to radiation reflected by the Earth-atmosphere system. A ground-based measurement station has been established at Hampton Institute to monitor solar radiation, atmospheric emitted radiation, local cloud cover, and atmospheric turbidity. Continuous measurements of global, direct and diffuse solar radiation, and atmospheric infrared radiation are made and stored by computer. NOAA GOES-EAST satellite data are used to obtain albedo and cloud cover information.

Interim analyses performed on the data include monthly averages of global insolation, infrared radiation, and atmospheric turbidity. Global insolation has been correlated with fractional cloud cover from March 1, 1981 through February 1, 1982 using the ARL empirical model.

(Supported by NASA grant No. NAG-1-87)

TROPOSPHERIC METHANE VALUES FROM THE EAST COAST. R.R. HINTON. Old Dominion Univ. Research Foundation, Norfolk, Va. 23508 and H.G. REICHLE, NASA Langely Research Center, Hampton, Va. 23665.

Methane data were collected by ODURF for the NASA Langely Research Center in conjunction with the development and testing of the Measurement of Air Pollution from Salellites (MAPS) instrumentation. Samples were taken at various altitudes during vertical spirals from the surface to altitudes as great as 12.5 km over several locations above the southeastern coastal piedmont and off the Atlantic Coast from 1976 to present. Methane concentrations were determined by flame ionization gas chromatography. Essentially the same analytical instrumentation, procedure, and calibration standards have been used during the six years spanned by the data set. In addition, the methane calibration standard has been confirmed directly by analysis at the National Bureau of Standards. Data are presented to demonstrate the stability of atmospheric methane levels and are clearly contrasted with some recently published values. The historical trend in nonurban tropospheric methane concentration is evaluated.

A STUDY OF THE FLUSHING ABILITY OF THREE SMALL EMBAYMENTS. Ronald E. Johnson, Dept. of Oceanography, Old Dominion University, Norfolk, VA 23508.

Estimations of flushing times for three different embayments bordering on or connecting to Chesapeake Bay have been made for private land developers. The model used assumes the worstcase condition of no freshwater inflow along with the assumption of no pollutant return on the following flood tide. The tide range, embayment depth and width then became the controlling parameters. Study 'A' involved a proposed partial fill on a tidal mud flat for commercial development. The results indicate that the flushing ratio of 0.76 would remain the same because the tidal prism would be changed in the same proportion as the total embayment volume. The large, 3.0 ft, tide range coupled with the wide shallow mud flat contributed to the very high ratio. Study 'C' involved a canal dredged to provide waterfront property. The low 1.2 ft, tide range coupled with the narrow canal led to a mid-range flushing ratio of 0.48. Study 'S' involved a series of canals with a mean tide range of 2.0 ft. The developer initially had desired such an excessive depth that the average flushing ratio was 0.25. By reducing the depth in a modified plan, the average ratio was increased to 0.37. Flushing ratios near 0.75 indicate that a single shot of pollutant will be flushed in less than 4 tidal cycles, while ratios near 0.25 will be flushed in approximately 20 cycles.

EFFECTS OF THE VARIATION OF RIVER DISCHARGE ON MIXING IN A HYDRAULIC MODEL. M. J. Jugan*. Department of Oceanography, Old Dominion University, Norfolk, Va. 23508

Data were collected from the Lafayette River branch of the Chesapeake Bay Hydraulic Model, Stevensville, Maryland in July, 1981. Three experiments were conducted, each successive experiment with an increase in the amount of fresh water discharged into the head of the river. The model was run with a tide of constant range and period simulating a quasi-steady-state condition. Batch releases of Rhodamine WT fluorescent dye were made across the channel from the mid-point of the river. Salinity and dye concentration data were collected at low and high water slack for ten tidal cycles. Salinity profiles indicate that as the fresh water discharge increased the model switched from well-mixed to stratified. As the dye was transported longitudinally, the concentration gradients were decreased. Temporal profiles show that the gradients became steeper as discharge increased for the stations around the release point. (Supported by Sea Grant.)

EVOLUTION OF PASSIVE REMOTE SENSING TECHNIQUE EXPERIMENT. J. V. Koziana*. Old Dominion University Research Foundation, Norfolk, Va. 23508

Four generations of a Gas Filter Correlation Radiometer (GFCR) have been developed at NASA LaRC under the Measurement of Air Pollution from Satellites (MAPS) program. The purpose of the MAPS program is to perform measurements of CO mixing ratios in the troposphere by applying the GFCR infrared passive remote sensing technique. The results of field test experiments from each of the GFCR instrument versions trace the success of the experiment development program and of the data reduction methodology. A discussion of significant MAPS data results beginning with the earliest version of the MAPS experiment utilized in the 1975 Albermarle Sound Flight Test to the current version of MAPS which was successfully flown in November 1981, as one of the five experiments comprising the first scientific payload flown on Space Shuttle. Significant improvements in the MAPS hardware design and the data reduction methods will be discussed. (This work was funded under NASA LaRC Grant NCC1-34)

CO MEASUREMENTS AROUND ST. PETERSBURG, FLORIDA, IN AUGUST 1978. J. V. Koziana*. Old Dominion University Research Foundation, Norfolk, Va. 23508

Measurements of tropospheric Carbon Monoxide (CO) mixing ratios were obtained from an aircraft platform near St. Petersburg, Florida, from August 14, 1978 to August 17, 1978, using a Gas Filter Correlation Radiometer (GFCR) remote sensing system. Carbon Monoxide mixing ratios were retrieved from the GFCR CO data by interpolating on a bivariate function generated with a line-by-line radiative transfer model. Meteorological data were obtained for the time period of the flight test and were incorporated in an analysis of the CO distribution in this urban mass region. (Funded by NASA LaRC Grant NCC1-34).

A SPACE INTERPOLATION SCHEME USING FNOC DATA ANALYSIS FIELDS. J. D. Lambeth*. Old Dominion University Research Foundation, Norfolk, Va. 23508

A latitude/longitude interpolation scheme was developed specifically to calculate any of the meteorological parameter values from the FNOC analysis grid which has a resolution of 381 km at 60° North Latitude. The interpolation scheme uses a second order least squares fit approach over the sixteen nearest grid points for the specified latitude/longitude of interest. Vertical profiles of density altitude, temperature, and dewpoint obtained utilizing this scheme were compared to radiosonde and aircraft meteorological data for several test cases. A comparison was also made between measured and computed sea surface temperatures. This interpolation technique is currently being tested in conjunction with the reduction of data obtained for the MAPS experiment flown by NASA on Space Shuttle in November 1981. This specific application requires a detailed knowledge of meteorological parameters in many geographical locations. (Aided by NASA LaRC Cooperative Agreement NCC1-34)

INCORPORATION OF ENVIRONMENTAL FACTORS AND MIGRATORY BEHAVIOR INTO A MODEL FOR PREDICTING YIELD OF BROWN SHRIMP (PENAEUS AZTECUS) IN PAMLICO SOUND, NORTH CAROLINA. M. A. Matylewich*. Dept. of Oceanography, Old Dominion University, Norfolk, Va. 23508

Crustaceans are extremely sensitive to environmental conditions, in comparison to other exploited marine organisms. Growth and natural mortality are directly influenced by environmental factors such as water temperature and salinity and annual yield is usually forecast on the basis of environmental factors in the nursery areas during times of development. Yield models utilizing environmental factors are generally static in nature. The migratory timing of a species, abundance as a function of time within a fixed geographic reference frame, can be used to construct a yield model which is dynamic. For brown shrimp the dynamic yield model utilizing migratory behavior was an improvement over the static yield model utilizing environmental factors. A yield estimation model which utilizes migratory behavior and environmental factors could lead to further improvement in the estimators.

LEACHATE MONITORING AT THE CHESAPEAKE, VIRGINIA LANDFILL. Britt McMillan* and J.H. Rule, Dept. of Geophysical Sciences, Old Dominion Univ., Norfolk, VA. 23508

Chesapeake Municipal landfill is located in a tidal marsh approximately 100 meters south of the Intracoastal Waterway. Presently only pH and Cl^- are monitored by the City of Chesapeake. A previous study (Rule, 1979) suggested the monitoring wells used by the City were too deep to detect leachate and subject to Cl^- contamination from the nearby Waterway. The present study involved a transect of pressure-vacuum lysimeters between the Waterway and landfill. There were four sites along the transect with lysimeters placed at one and three meters. One meter lysimeters were in a perched water table and three meter lysimeters penetrated the upper portion of the local shallow aquifer. Conductivity, salinity, Na, Cl, and Mg concentrations showed influence from both the Waterway and leachate TKN, K, Fe, and Ca from leachate, and PO_4 from the Waterway.

JUVENILE SURVIVAL OF STLANTIC CROAKER--A PREDICTIVE TECHNIQUE. Brenda L. Norcross, Herbert M. Austin (Virginia Institute of Marine Science, College of William and Mary, Gloucester Point, VA 23062), Sharon K. LeDuc* (NOAA/EDIS, Center for Environmental Assessment Services, Columbia, MO 65201), Merton C. Ingham* (NOAA/NMFS, Atlantic Environmental Group, Narragansett, RI 02882).

Winter temperature-induced mortalities of juvenile Atlantic croaker (Micropogonias undulatus) have been observed in the field and laboratory. Preliminary efforts have quantified the relationship between winter temperature and subsequent survival of juvenile croaker the following summer. Examination of the data reveal that the effect of this environmental factor on total juvenile survival is greater during the years when the commercial catch (an indication of spawning stock size) is low. Based on this technique poor year classes for croaker in the Chesapeake Bay are predicted for 1980-81 and 1981-82.

"Relation of Size Class Distribution to Migratory Behavior in the Brown Shrimp (Penaeus aztecus) in Pamlico Sound, North Carolina." Mario A. Paula,* Dept. of Oceanography, ODU. Norfolk, VA 23508

The migratory timing of a species is defined by the abundance as a function of time within a fixed geographic reference frame. Several aspects of the migratory timing of this species can be investigated by taking advantage of commercial catch data in Pamlico Sound which is recorded by average size (count per pound). The model used for this purpose provides descriptive statistics, a mean migration time and a variance, for each size class. An associated empirical probability density specifies the probability of occurence of each time interval with respect to size class. By determining the distribution of size classes within Pamlico Sound the pattern of recruitment into the fishery may be inferred. Continous recruitment would be indicated by the existence of several size classes on a given time interval, while discrete (step-wise) recruitment would be indicated by segregation of size classes on a given time interval. The proportion of the observed interannual variability attributed to combining size classes is investigated. If the interannual variability is not significantly reduced by segregating the population into several size classes, then environmental factors would be indicated as the major source of variability.

APPLICATION OF AMES SALMONELLA TESTING TO DETECT ACCUMULATED MUTAGENS IN OYSTERS FROM THE SOUTHERN CHESAPEAKE BAY. Charles A. Pittinger and Arthur L. Buikema, Jr. University Center for Environmental Studies and Dept. of Biology, Virginia Polytechnic Institute, Blacksburg, Virginia 24061.

Samples of oysters (Crassostrea virginica) collected in October and December of 1981 from heavily-impacted locations in the southern Chesapeake Bay were screened for mutagenic activity by the Ames Salmonella assay. Blended aliquots (50 or 100 g wet weight) of each sample were extracted with diethyl ether, frozen, reduced by rotary evaporation, and resuspended in 10 ml DMSO. Extracts were tested using Ames strains TA98 and TA100, in the presence and absence of Arochlor 1254-induced rat liver S9 preparation. Extracts were also analyzed by gas chromatography, with a 20 foot SP-2100 column and flame ionization detector (12 ml/min N_2; temperature programmed from 175 to 285° C.).

Significant dose-responses were observed with strains TA98 and/or TA100 (without S9) from several extracts of fall samples; no activity was detected in winter samples. Toxicity was encountered in several tests using S9. Modes of mutagenesis (frameshift verses base-substituion) also differed among samples. Chromatographic analyses suggest differences in tissue concentrations of xenobiotics which may be related to observed trends in mutagenicity.

OPERATIONAL RESULTS FROM THE MEASUREMENT OF AIR POLLUTION FROM SATELLITES (MAPS) EXPERIMENT FLOWN ONBOARD THE STS-2 (SHUTTLE). Mary S. Saylor, Old Dominion University Research Foundation, Norfolk, Va. 23508

A 1976 proposal to fly a gas filter radiometer in space was realized with the November 12, 1981, launch of the STS-2 (space shuttle). The Measurement of Air Pollution from Satellites (MAPS) experiment, part of the first scientific payload flown on the space shuttle, was designed to measure the distribution of CO in the mid-troposphere. The radiometer operated approximately 42 hours and achieved excellent nadir viewing coverage of the Earth in a latitudinal band ranging from 38°N to 38°S. A camera loaded with false color infrared film photographed the footprint of the MAPS experiment during periods of daylight. Auxiliary data were obtained via aircraft underflights flown from the East Coast, the West Coast, and Australia: a prototype of the MAPS experiment, the brassboard instrument, was flown on a NASA Learjet and operated at altitudes up to 41,000 feet, and in situ air samples were collected and meteorological conditions were recorded on all correlative flights. Analysis of experimental data from all sources is progressing satisfactorily, with the expectation that CO mixing ratios for the global band specified will be available by December 1982. (Aided by NASA LaRC Cooperative Agreement NCC1-34)

QUANTITATIVE ASPECTS OF MIGRATORY TIMING OF ADULT CHINOOK SALMON (ONCORHYNCHUS TSHAWYTSCHA) IN THE LOWER YUKON, ALASKA. Howard A. Schaller*, and P.R. Mundy. Dept. of Oceanography, Old Dominion Univ.,Norfolk,Va. 23508

Migratory timing is abundance as a function of time within a fixed geographic reference frame.Abundance of chinook salmon (O. tshawytscha) measured by catch per unit of effort inthe major statistical fishing area of the Yukon River (Alaska) has been determined for a 21 year period(1960-1980).

Cumulative migratory time densities, based on the catch per unit of effort, demonstrate remarkably small interannual variation.However, the variation is large enough to render the average migratory timing distribution inaccurate for use as an abundance estimator for fisheries harvest management.

The annual migrations were subsequently stratified aposteriori into early, late, and average migrations according to the mean date (day number on which approximately 50% of the migration has passed the geographic reference frame). Further apriori stratification into warm, average, and cool temperature migrations was accomplished according to the mean air temperature recorded for the month of April. The stratified migratory timing (using the temperature data) improves the use of this information for abundance estimation, for the Lower Yukon chinook salmon.

EFFECT OF ESTUARINE MIXING ON THE DISTRIBUTION AND FATE OF ORGANIC MATTER. D. J. Velinsky and T. L. Wade, Dept. of Oceanography, Old Dominion University, Norfolk, VA 23508.

Estuaries act as a semi-permeable membrane between river and ocean waters. The processes that occur within the estuaries determine the concentration and composition of materials that leave or enter the ocean. Salinity is used as a conservative tracer of ocean water allowing for the determination of non-conservative or conservative behavior during mixing.

Surface water samples of various salinities were collected in the James River and lower Chesapeake Bay. Organic carbon, hydrocarbon and fatty acid concentrations were determined for both the dissolved and particulate phases. The absorbances at 280nm of filtered samples were measured.

The results of this study indicated that specific organic materials were being removed at low salinities, whereas other organics were simply diluted by conservative mixing. Dissolved organic carbon exhibited conservative mixing between salinities of 0.4 o/oo and 26.4 o/oo, while sample absorbances decreased exposentially. Hydrocarbon concentrations decreased with increasing salinity. Dissolved hydrocarbons were undetectable in samples with salinities of 5 o/oo or greater, while particulate hydrocarbons were detected in all samples. Polycyclic aromatic hydrocarbons, benzo(a) pyrene and pyrene, were found only in low salinity water (5 o/oo), while chrysene was found at all salinities. Preliminary results showed that certain biogeochemical processes within the estuarine environment affect the fate of organic materials.

LABORATORY AND FIELD-DETERMINED AVOIDANCE RESPONSES OF FISH TO ACIDIC AND ALKALINE pH LEVELS. James B. Whitaker*, Donald S. Cherry*, John Cairns, Jr. and David A. Stetler*. Univ. Ctr. for Environmental Studies and Dept. of Biology, Va. Polytechnic Inst. and State Univ., Blacksburg, VA 24061.

Laboratory avoidance studies were carried out in order to investigate the potential role of avoidance behavior which may alter fish distributions in acidic and alkaline waters. Under laboratory conditions of continuously decreasing pH, stonerollers (Campostoma anomalum) first avoided pH 6.0 and 6.5 at 18° and 24°C while rainbow trout (Salmo gairdneri) avoided pH 6.5 and 6.0 at 12° and 18°C, which was a sublethal response 2 to 2.5 units above the 96 hr LC50 of 4.05 for trout. Alkaline conditions elicited avoidance responses at pH 10.0 at 18° and 24°C for stonerollers and pH 11.0 and 10.5 at 12° and 18°C for trout, which exceeded the 96 hr LC50 of 9.11.

The effluent from the fly ash settling basin of the Glen Lyn Power Plant was released into Adair Run, a second order mountain stream. As the basin filled, the pH of the effluent increased up to pH 9.6. Fish communities were sampled above and below the outfall for 15 months. The effluent contributed to a downstream decline in species diversity and an increased dominance of the stoneroller, which displaced more sensitive species. (Funded by American Electric Power Service Corp., Canton, OH 44701.)

THE LOCATION AND EXTENT OF THE PRODUCTIVE OYSTER GROUNDS IN THE JAMES RIVER, VIRGINIA. J. P. Whitcomb* and D. S. Haven. Dept. of Applied Biology, VA Inst. of Mar. Sci., The Col. of William and Mary, Gloucester Point, VA 23062.

Virginia's public oyster grounds (Baylor Grounds) were surveyed by VIMS between 1976 and 1980, using electronic positioning gear, to determine the acreages of bottom suitable for oyster culture. Parameters measured were oyster shell and oyster density, and the extent of mud or sand bottoms.

Prior to this study only the James River had been surveyed (1911); in other areas only the location and acreage of the public bottom was known.

This paper discusses the James River which is the state's most productive seed oyster growing area. The study showed large areas of unproductive bottom in the James (35.4%). Locations of the productive bottom in 1911 were found in the same approximate locations during the 1976-1980 period.

Geology Section

EFFECTS OF AGNES ON A YORK RIVER BEACH, S. O. BIRD, Virginia Division of Mineral Resources, Charlottesville, Va. 22903

Tropical storm Agnes (June 21, 1972) generated significant wave heights of some 4' on the York River. Maximum erosion on a beach protected by bulkheads lagged behind the time of maximum wind velocities by a few days. This lag resulted from removal of sediments offshore (at depths of some 5'); erosion progressed shoreward. In the sequence, as waves broke on the beach, a new base level of erosion was cut into the Yorktown Formation underlying the beach deposits. The resulting beach profile was some 5^{o} steeper than the pre-storm one. Material added to the beach after maximum erosion remained steep (about 10^{o}).

Beach sediments were coarser on the steeper beach than the earlier one; size distribution was in accordance with the null-point hypothesis. Size analyses of samples taken to depths of 8 inches did not reveal "an expected" relationship between depth and grain size.

Analyses of tidal heights and arrival times show that Agnes produced a complex wave form, whose period is too long to be a standing wave.

OSTREA FROM THE EASTOVER AND YORKTOWN FORMATIONS OF SOUTHEASTERN, VA. C. L. Cecca, Dept. of Geology, Col. of William and Mary, Williamsburg, Va. 23185

Ostrea sculpturata, O. compressirostra, O. raveneliana, and Pycnodonte sp. were recovered from the Eastover and Yorktown formations. O. compressirostra is limited to the upper part of the Cobham Bay Member of the Eastover Formation and to the Sunken Meadow Member of the Yorktown Formation. Pycnodonte sp. is confined to the Sunken Meadow Member of the Yorktown Formation. O. sculpturata and O. raveneliana are found in the Rushmere, Morgarts Beach and Moorehouse members of the Yorktown Formation. O. compressirostra is recognized by the exterior corrugatus, variable growth of oracles, lunate muscle scar, and short faint chomata. O. ravenelianas convex valve is less ornate than O. compressirostra and lacks corrugatus. It has a lunate muscle scar and short chomata. The plicated shell distinguishes O. sculpturata from the other Ostrea. A short row of chomata occurs on each side of the hinge. Vesicular shell structure, round muscle scar, commissural shelf, and distinctive chomata are attributes of the Pycnodonte sp. This species imitates O. compressirostra in its ornateness. The stratigraphic distribution of Ostrea within the Eastover and Yorktown formations is attributable to evolution and migration.

PLEISTOCENE DEPOSITIONAL PATTERNS OF THE SOUTHEASTERN VIRGINIA AND NORTHEASTERN NORTH CAROLINA COASTAL PLAIN. G. H. Johnson, P. C. Peebles, and C. R. Berquist, Va. Division of Mineral Resources, Col. of William and Mary, Williamsburg, Va. 23185

Pleistocene deposits in southeastern Virginia and northeastern North Carolina typically occur as fining upward sequences in river and coastwise flats. Each flat, possibly as many as seven, is morphologically distinct and lies at progressively lower elevations from west to east and toward the rivers. The base of the sequence contains fluvial and paludal deposits (channel sand and gravel, clay, and organic-rich deposits) and/or reworked fluvial deposits (sheets of gravel lag). The upper part of the sequence contains fine sand, silt, or clay of riverine estuary, bay-lagoon or shallow nearshore marine origin. In the vicinity of submarine or subaerial barriers, the vertical sequence coarsens upward.

Within each flat the west to east lateral variation in sediments corresponds to fluvial, estuarine, bay-lagoonal, barrier and shallow marine environments. Each flat is related to a sea level change, primarily attributable to a marine transgression.

AN EXERCISE IN NON-ORTHOGONAL CRYSTALLOGRAPHIC PROJECTIONS. Maureen M. Julian. Department of Geological Sciences, Virginia Polytechnic Institute and State University, Blacksburg, VA 24061

Most crystalline materials do not crystallize in a cubic space group, hence it is necessary for the student to become familar with the lower symmetries. One- and two- dimensional models are often so artifically contrived as to appear superficial. This paper will explore, from a pedagocial viewpoint, some of the extraordinary features of crystal structure of hexamethyl benzene. There is only one molecule to the unit cell, the structure is planar and all of the non-hydrogen atoms of the molecule are completely contained in the (001) plane. The projection onto the ab plane is particularly interesting. Since the crystal is triclinic, the concept of non-orthogonal axes is immediately introduced. This exercise also helps in the concept of bonding, since the students had to make decisions as to where the bonds are formed.

THEORETICAL CALCULATIONS OF OPTICAL PROPERTIES OF ANTHRACENE. Maureen M. Julian. Department of Geological Sciences, Virginia Polytechnic Institute and State University, Blacksburg, VA 24061

The relationship between the optical anisotropic properties and the molecular shape and packing supplies a good internal check on the optical and structural data and also gives information that can be correlated with the magnetic anisotropies. The derivation of the relationship between molecular and crystalline refractivities will be done. The calculated value for mu is 6.6 degrees and the observed value is 7.5 degrees. In biaxial crystals, measurement of the angle between the two optic axes, 2V, is constant for a given crystal, at a given temperature and for a given wavelength. A study of the optical properties of anthracene was done because of conflicting results in the literature and because recently developed techniques introduce computer and statistical methods into the practice of optical crystallography permitting greater accuracy. For anthracene at 20 degrees C, 2V=90.0 (1.8) degrees at 540 nm, and 2V=89.4 (1.8) degrees at 900 nm. The optical and diamagnetic data will be compared.

CHRONOLOGY AND CHEMISTRY STUDY OF THE CATOCTIN FORMATION, VA. Douglas Mose, Susan Nagel, and Deborah Kobilis, Department of Geology, George Mason University, Fairfax, Virginia 22030

Chemical analyses from the Catoctin Formation show that the Catoctin is a tholeiitic basalt of within-plate tectonic affinity. The basalt has been altered by metamorphism, surface processes and incorporation of host rock. These factors are important in trying to understand why radiometric age determinations yield conflicting results. A U-PB zircon study yielded an age of about 800 m.y. (too old due to xenocrystic zircons). A Rb-Sr whole-rock study yielded an age of 470 $\pm$ 77 m.y. (too young due to Taconic metamorphism). A RB-Sr study of the Rockfish River and Robertson River plutons which are cut by possible feeder dikes of the Catoctin flows show that the Catoctin is no older than about 585 m.y.. This assumes that the dikes are actually feeder dikes for the Catoctin; this seems reasonable because there is a close chemical similarity between the Catoctin flows and the dikes. This maximum age for the Catoctin and the early Cambrian age for the overlying Chilhowee Formation shows that the Catoctin is a latest Precambrian to early Cambrian formation.

CLAY MINERALOGY OF THE BLUESTONE FORMATION IN THE UFG POCAHONTAS 9138-T WELL, BUCHANAN COUNTY, VIRGINIA. Jack E. Nolde*. Va. Division of Mineral Resources, Charlottesville, Virginia., 22903

Semi-quantitative determination of clay mineralogy have been made on 19 samples of the Bluestone Formation (Upper Mississippian) from the UFG Pocahontas 9138-T well in Buchanan County, Virginia. The upper part of the Bluestone Formation in this well is primarily a redbed sequence. The red siltstones are mottled with grayish-green spots and interbeds of grayish-green siltstones are common. The grayish-green color is attributed to reduction of ferric iron oxide to the ferrous state by oxidation of organic matter. The lower part of the Bluestone consists of dark-gray to black shale, the Pride Shale Member.

X-ray diffraction and DTA data show that no montmorillonite is present and that illite, mixed-layered, chlorite, and kaolinite are abundant. The data also show the degree of crystallinity of all the clay minerals is constant from the lower part to the upper part of the Bluestone Formation.

Clay mineral and paleontological evidence suggests the following depositional environments, in ascending order: back barrier lagoon (illite about equal amounts to chlorite + kaolinite), and clay-rich tidal flat (illite about three times more abundant than chlorite and kaolinite). Tidal flat deposits are red.

SHALLOW GROUNDWATER CONTAMINATION FROM A FLYASH DISPOSAL SITE IN YORK COUNTY, VIRGINIA. R. R. Oakes, Department of Geology, Coll. of William and Mary, Williamsburg, Va. 23185

Leachate from a flyash disposal site in lower York County, Va. has contaminated domestic wells in the shallow groundwater aquifer with vanadium, selenium, and sulfates. The flyash is underlain by the permeable sandy beds of the late Pleistocene Sedgefield and Lynnhaven members of the Tabb Formation, and in places by the less permeable, silty-fine sand of the Pliocene Yorktown Formation. The piezometric surface, determined by borings, mimics the topography, and slopes away from the pit in all directions except to the south. Leachate migration away from the pit was confirmed by State Water Control Board water analyses. The leachate migrates laterally from the pit through the Sedgefield member of the Tabb Formation in all directions except to the south. The leachate seeps into Chisman Creek. The physical and chemical properties of Yorktown Formation limit the known downward movement of the leachate.

DEEP OCEAN MINING - MANGANESE NODULES. W. D. Siapno, Director of Marine Science, Deepsea Ventures, Inc., Gloucester Point, Virginia 23062

Manganese nodules discovered over a century ago by HMS Challenger are now considered resources destined for development in the near future. Deepsea Ventures, an international consortium, formed by U.S. Steel, Sun Oil, Union Miniere, Samim and Tenneco have applied for an exploration license in the eastern portion of the Clipperton-Clarion Fracture Zone in the northeastern Pacific. This presentation discusses exploration and mining procedures. Upon processing, nodules will yield copper, nickel, cobalt and manganese.

These are pioneering efforts with mining operations taking place in water depths of approximately 15,000 feet. Domestic resources of these materials with the exception of copper are in short supply. As the world population moves toward a more sophisticated lifestyle, new sources of materials will be required to maintain acceptable standards of living. In time of international unrest when normal trade is restricted, control of fundamental resources is of paramount importance.

NEW EARLY MISSISSIPPIAN SYNCARID CRUSTACEAN FROM THE PRICE FORMATION, VIRGINIA. Brenda Tczap* and C.G. Tillman*. Dept. of Geol. Sci., Virginia Polytechnic Inst. and State Univ., Blacksburg, Va. 24061.

The Price Formation (Early Mississippian) in Virginia and neighboring states contains shallow marine fossil brachiopods, bivalves, bryozoans, and crinoids, and fossil plants, undescribed eurypterids, and several arachnids. A probable fresh- or brackish-water fossil syncarid crustacean was discovered recently on a small outcrop of greenish-gray to buff-colored shaly mudstone in the Price Formation 10.5 km northwest of Pulaski along Virginia Route 738.

The syncarid is 7.5 cm long and is essentially linear, laterally compressed and has 12 preserved segments. No carapace or well-defined thorax-abdomen junction is visible. Cardiopteridium, a floral guide fossil of the Price Formation, is known locally only from this exposure and occurs with the syncarid.

PULSED SUBSIDENCE AND LITHOFACIES CYCLICITY IN THE BEEKMANTOWN FORMATION, LEXINGTON, VA. H. A. Quinn, G. L. Benedict, Dept. of Geology, Col. of William and Mary, Williamsburg, Va. 23185

The Beekmantown, near Lexington, Va., is conspicuous in its alternation of light and dark gray strata. Detailed thin-section analysis reveals that this alternation is associated with a change in biota. Marine biotic allochems present in the dark gray strata, are absent in the light gray strata. Specifically, the dark strata comprise pelleted mudstones characterized by stenohaline taxa, while the light strata are predominantly nonfossiliferous, algally laminated dolostones. Field observation reveals desiccation cracks and crenulated algal mats within the light units. Flat pebble conglomerates are found between the two units. This cyclic fluctuation in both lithology and biota records a significant change in depositional environments. The model herein proposed to explain the cyclicity is one of rapid, intermittent, tectonically controlled basement down-dropping. The resulting cyclic subsidence causes a relative rise in sea level allowing the establishment of carbonate producers and increased rates of carbonate sedimentation. During the intermittent periods of quiesence, carbonate sedimentation aggrades to mean sea level. Recurrence of subsidence allows for the repetition of the carbonate production cycle, which is recorded as lithofacies alternation.

AN INVESTIGATION OF THE NARROWS LANDSLIDE, Giles County, Virginia. W. J. SAMFORD*. Dept. Geol. Sci., Virginia State University, Petersburg, Va. 23803

The Narrows Landslide consists solely of overturned sandstones and shales of the Silurian Rose Hill Formation. These rocks are located on the footwall block of the Narrows fault and during overturning and thrusting, were severely fractured and locally brecciated. Now on a south-facing cutbank slope of the New River, the strata dip southward, sub-parallel to the hillside and towards U. S. Route 460.

This study was undertaken from January through September 1981 and shows that the inherent instability of the hillside, due to the sandstone/shale lithologies and structure, has combined with ground water infiltration and undercutting of the toe of the slope by highway construction to produce discontinuous movement of the landslide since 1940. Movement has been punctuated by nearly diastrous slides and has cost Virginia over one million dollars in remedial measures and maintenance. The continued slow movement documented during this study indicates that more study and remedial work needs to be done.

WHATEVER HAPPENED TO THOSE "MARKER" BEDS IN SUBSURFACE BUCHANAN COUNTY? J. K. Polzin*/J. E. Nolde*. Virginia Division of Mineral Resources, Charlottesville, Virginia 22903.

Recent subsurface investigations in the Upper Mississippian Bluestone-Hinton-Bluefield sequence of Buchanan County, Virginia has shown that certain units in the Hinton Formation can no longer be regarded as marker beds.

The units to be considered are the Princeton Sandstone, the Tallery Sandstone, the Little Stone Gap, the "Maxon" sands of drillers usage and the Stony Gap Sandstone.

The Princeton, considered to be a continuous unit above the Hinton is found to pinch out in the Keen Mountain Quadrangle area overlying a pinch-out of the Tallery Sandstone Member of the Hinton. The Little Stone Gap Member is relatively constant across Buchanan County and can still be used as a "marker" bed, while the "Maxon" sands are shown not to be correlative throughout the area. Last, the Stony Gap Sandstone Member, considered the base of the Hinton, is a complex inter-tonguing sandstone-siltstone-channel sand facies.

This project was funded under a U.S.G.S. Grant-Southwestern Virginia Hydrology Study-429.

DIAGENETIC CEMENTATION PATTERNS OF A MIDDLE ORDOVICIAN TIDAL FLAT, NINA, TN., E. M. Sullivan, G. L. Benedict, Dept. of Geology, Col. of William and Mary, Williamsburg, Va. 23185

The Nina locality of the Mosheim Formation of Eastern Tennessee, comprises sparsely fossiliferous, ostracode-bearing, pelletized, micritic limestone of Middle Ordovician age deposited in a large shallow marine/brackish water tidal flat complex.

Standard and cathodoluminescent (CLM) petrographic techniques indicate considerable variation in the style and type of cementation present at Nina. Meteoric/vadose fabrics and cements are restricted to the base of the unit and include equant void filling calcite mosaics of coarsening inward crystals, pendant cements and crystal silt. CLM reveals large zoned scalenohedra growing normal to the substrate and characteristically exhibiting a luminescent sequence of dark, bright, dull cements. In contrast, the upper part of the section at Nina exhibits marine cements. These include prismatic, often turbid, void filling crystals which grow normal to the pore substrate and become more elongate toward the void center. With CLM, these prismatic crystals exhibit a luminescent sequence of dark, bright, dull cements. This change from meteoric/vadose to marine cementation was apparently controlled by relative proximity to the adjacent transgressive marine environment.

A MINERALOGICAL STUDY OF SMALL PEGMATITE-LIKE BODIES NEAR ALTAVISTA, VIRGINIA. David L. Woolley*, Commonwealth of Va. Dept. of Highways and Trans., Lynchburg, Va.; Ernst F. Koehler* and John M. Renard*, Dept. of Environmental Sciences, Univ. of Va., Charlottesville, Va.

Pegmatite-like bodies are located in a railway cut along the Staunton River at the confluence of the Otter River approximately one mile northeast of Altavista, Virginia. The outcrop occurs in the southern termination of the Sherwill anticline. The host rock is the upper amphibolite (magnetite-rich) of the Bassett Formation. Unlike typical pegmatites, the major minerals of these bodies are sodic plagioclase and quartz. Associated zones are rich in magnetite, euhedral to subhedral apatite, biotite, and large, platy subhedral hematite crystals with exsolved ilmenite. Other zones in the pegmatite-like bodies are rich in quartz with associated chalcopyrite and with bornite replaced by digenite and covellite. Secondary malachite is also present. Other minerals observed are epidote, sphene, muscovite, and amphiboles. Nearby pegmatites containing beryl, pyrrhotite, galena, and other minerals are known in the overlying Fork Mountain Formation.

Materials Science Section

THE FRACTURE OF Ti-8Mn ALLOY, J. I. Bennetch and H. G. F. Wilsdorf, Materials Science Dept., Univ. of Va., Charlottesville, Va. 22901

The Ti-8Mn commercial alloy is a useful binary Ti alloy with Mn serving to stabilize the β phase. In order to study this particular alloy, a quantity of Ti-8Mn sheet was obtained that had first been rolled and then vacuum annealed to produce an equilibrium two phase α-β structure, as verified by stereological measurements. However, the two phases were not equiaxed, as expected, but rather seemed to be elongated and flattened parallel to the rolling direction. In addition, the alloy exhibited a pronounced recrystallization texture, as evidenced by relative peak height elevations of both the $(0002)\alpha$ and $(002)\beta$ reflections in an X-ray diffractometer. Tensile tests of the alloy were carried out in an Instron testing device at room temperature. In general, values for 0.2% yield strength, elongation and ultimate tensile strength obtained were comparable to published values. The dimpled appearance of its fracture surface, characteristic of ductile failure, was revealed in a scanning electron microscope (SEM). Direct imaging of the two phases on the fracture surface was made possible by means of various SEM modes. This technique showed that α-β grain boundaries apparently do coincide with some dimple walls. Unexpectedly, cleavage-like regions were also present on the fracture surface. X-ray maps of these regions revealed a relative depletion of Ti in comparison to the dimpled regions.

AN ELONGATION MAP ABOUT A CRACK TIP, J. I. Bennetch and W. A. Jesser, Materials Science Dept., Univ. of Va., Charlottesville, Va. 22901

In theoretical fracture mechanics, the shape of the strain field in front of a crack tip is very important for understanding crack propagation in materials. In the past, experimentalists usually have determined the shape of the field by first placing a grid on the surface of a tensile sample. Then, during tension, the distortion of the grid enables the construction of an elongation map of limited resolution, which in turn is related to the strain field surrounding the primary crack. Alternatively, cavities or bubbles that naturally form in metals as a result of ion or neutron irradiation provide closely spaced internal markers. If such an irradiated microtensile sample is pulled in-situ in a high voltage electron microscope (HVEM), both the relative displacement of these cavities and their distortion in shape provide information on localized strain on a much smaller microscopic level than that obtained by the grid method. In addition, this HVEM technique allows direct correlation of slip systems with crack propagation characteristics. To demonstrate this latter technique, an elongation map was constructed about a crack propagating in a helium irradiated type 316 stainless steel microtensile sample containing large helium filled bubbles.

ENVIRONMENTAL EFFECTS ON THE FRACTURE TOUGHNESS OF POLYMETHYL METHACRYLATE. T. J. Watson, G. H. Bray and M. R. Louthan, Jr. Virginia Polytechnic Institute, Blacksburg, Va. 24061

The apparent plane-strain fracture toughness of polymethyl methacrylate was much higher in room temperature tests with the sample immersed in either water, methanol or acetone than in similar tests in dry air. Test specimens were sized according to ASTM specification E-399 to insure plane-strain conditions. The increased fracture toughness in the liquid environments is attributed to release of constraint due to environmentally induced crazing at the crack tip. Metallographic and fractographic observations support this hypothesis and show extensive secondary or branched cracks accompany fracture in the liquids while the crack front in air is sharp and smooth.

DUAL SORPTION MODEL FOR DIFFUSION IN POLY (p.PHENYLENE BENZOBISTHIAZOLE). Wu-Song Huang and R. E. Barker, Jr. Dept of Materials Science, UVA, Charlottesville, VA 22903.

When combined with other techniques, the study of sorption (s) and diffusion (D) provides a valuable way to enhance the understanding of certain types of molecular interactions in polymeric systems. Measurements of s and D for PPBT, which is an extended chain (rigid rod) type polymer, give very different results depending on whether the observations were carried out in a vaccum chamber to which the diffusant (H_2O) was subsequently admitted, or carried out in air on previously desiccated samples. It has been possible to resolve the differences by assuming a dual sorption model wherein the micro-voids sorb according to a Langmiur isotherm and the other portions of the polymer obey Henry's law.(This research was supported by US Air Force Grant 80-0014A).

TEM STUDIES OF THE OXIDATION OF V-20Ti. S. A. Hackney* and K. R. Lawless Dept. of Materials Science, Univ. of Va., Charlottesville, Va. 22901

The low-pressure oxidation behavior of V-20Ti alloy has been studied using transmission electron microscopy (TEM) combined with Auger electron spectroscopy (AES) and weight gain analysis. The results have been compared with the low pressure oxidation of pure vanadium, showing that the oxidation resistance is improved by the addition of titanium. Analysis of oxidized bulk specimens by TEM and AES reveals the presence of a surface oxide layer enriched in titanium. Electron diffraction of thin films (oxidized in-situ) and electrochemically thinned bulk specimens (oxidized in UHV system) show no evidence of the long range order present in the vanadium-oxygen system; however, TEM and AES data indicate that dissolved oxygen reacts preferentially with titanium. (This research was partially supported by the Basic Energy Sciences Division, USDOE, through the SHaRE program.)

EVIDENCE FOR THE APPLICABILITY OF AN ANISOTROPIC VERSION OF THE WEAK-ELECTROLYTE THEORY TO IONIC CONDUCTIVITY IN EXTENDED CHAIN POLYMERS. D. Y. Chen* and R. E. Barker, Jr. Dept. of Materials Science, Univ. of Va., Charlottesville, Va.22901

Several years ago Barker and Sharbaugh demonstrated that the mathematical model for aqueous solutions of weak electrolytes could be adapted to provide a useful description of many of the observed phenomena in low conductivity systems such as organic liquids and polymers. Recent work involving a highly anisotropic (extended chain) polymer, poly-paraphenylene benzobisthiazole (PPBT), showed some persuasive evidence for the applicability of the weak-electrolyte theory. A mixed ionic and electronic conduction is proposed based on a detailed analysis of the data in view of the weak-electrolyte theory. The conclusion is that intrinsic and extrinsic ionic species are dissociated as a result of exposing PPBT samples to a conditioned humid environment. The experimentally observed transient phenomena which accompanied these dissociation processes will be discussed to further support the applicability of the weak-electrolyte theory.

FATIGUE CHARACTERIZATION OF CU-NI TO STEEL WELDMENTS. J. G. Cotner* and J. H. Wilson*. Dept. of Agricultural Engineering, Va. Polytechnic Inst. and State Univ., Blacksburg, Va. 24061.

Biofouling of ship hulls is a major economic problem in the shipping industry. The increase in drag caused by biofouling-induced roughness causes a substantial decrease in fuel economy. This loss in fuel economy has led the shipping industry to consider copper cladding as a means of eliminating the formation of barnacles. A 90-10 copper-nickel alloy is being considered as the cladding material. The cladding material may be welded to the shiphull using a model 190 welding rod.

The major drawback at the present time in using a loose cladding process is the lack of applied engineering data on the strength characteristics of copper-nickel to steel weldments. The purpose of this investigation was to establish the fatigue characteristics of copper-nickel steel weldments.

Fatigue tests were conducted in pulsating tension with a stress ratio of zero. The results of this investigation showed that for the specimen geometry use, all fatigue failures occurred in the copper-nickel cladding material. The fatigue cracks nucleated in the copper alloy, propagated through the copper alloy and avoided running into the monel weld. These results indicate that the weld will withstand cyclic loading.

THE PRODUCTION OF DENTAL ALLOY VIA CHEMICAL VAPOR DEPOSITION IN A FLUIDIZED BED. C. Boyer and L. B. Johnson*. Dept. of Materials Science, U. of Va., Charlottesville, Va. 22901

The object of this research was to develop a low Ag content dental alloy. The alloys were prepared by depositing Ag and Sn on spherical particles of Cu, ranging in diameter from 5 to 40 μm. The deposit was obtained by a process of chemical vapor deposition in a fluidized bed. The compressive strength tests of amalgams made with the alloy ranged from 5 to 16,000 psi.

RATES OF REDUCTION OF ZINC FROM $ZnFe_2O_4$ AND FROM Zn_2SiO_4. T. P. Floridis and W. R. Hibbard, Jr. Dept. of Materials Engineering, Va. Poly. Inst. & St. Univ., Blacksburg, VA 24061

Roasted zinc concentrates contain zinc ferrite ($ZnFe_2O_4$) and zinc orthosilicate (Zn_2SiO_4) besides zinc oxide (ZnO). The rates of reduction of zinc from $ZnFe_2O_4$ and from Zn_2SiO_4 were compared to the rates of reduction of zinc from unreacted mixtures of ZnO and Fe_2O_3 and of ZnO and SiO_2 having the same respective mass ratios of the component oxides as the $ZnFe_2O_4$ and Zn_2SiO_4. Carbon monoxide and hydrogen were the reductants. The hydrogen was used as a mixture of 90% Ar-10% H_2. The reduction temperature was 1300°K. The particle size was ranging from 44 to 74 μm. The rate of reduction of zinc from zinc ferrite is 98% and 65% of the rate of reduction of zinc from unreacted mixtures of ZnO and Fe_2O_3 when the reductants are carbon monoxide and hydrogen (90% Ar-10% H_2), respectively. The decreases in the rate of reduction of zinc from zinc orthosilicate are more pronounced dropping to the 16% and 29% of the rate of reduction of zinc from the unreacted mixtures of ZnO and SiO_2 when the reductants are carbon monoxide and hydrogen (90% Ar-10% H_2), respectively.
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TENSILE PROPERTIES AND CRACK PROPAGATION CHARACTERISTICS OF STAINLESS STEEL MICROSPECIMENS. R. D. Gerke and W. A. Jesser. Dept. of Materials Science, Univ. of Va., Charlottesville, Va. 22901.

A quantitative load-elongation hot tensile stage has been used to study fracture during in-situ tensile testing of type 316 stainless steel foil microspecimens in a high voltage electron microscope (HVEM). The micro-tensile specimens, 40 μm thick and 12.5 mm x 2.5 mm, were solution annealed and electrothinned to electron transparency in a central circular region which is surrounded by a region having the original thickness of 40 μm. Three specimen conditions were investigated in order to relate macroscopic properties observed in the load-elongation curves to the microscopic phenomena observed in the HVEM: 1) unirradited and tensile tested at room temperature, 2) unirradiated and tensile tested at 400° C, and 3) neutron irradiated at ambient temperature to a fluence of 1 x 10^{-}-n/m^{2} in the RTNS II facility at the Lawrence Livermore Laboratory and tensile tested at room temperature. Tensile properties have been compared to tensile properties for bulk specimens. These properties were also correlated to the manner in which the main crack propagates through the electrothinned region of the material. The combined use of macroscopic and microscopic properties such as the load curve, crack length (cumulative) and crack angle vs. total elongation provide a method to quantify specimen ductility.

THE INFLUENCE OF FIBER ORIENTATION ON THE STRESS WAVE FACTOR TECHNIQUE. A. Govada and J. C. Duke, Jr. ESM Dept., VA Polytechnic Inst. & State Univ., Blacksburg, VA 24061-4899

The Stress Wave Factor (SWF) is a new technique for the nondestructive evaluation of composites. This technique has been found to be sensitive to a number of experimental parameters. Different fiber orientations in the outermost ply of the composite laminate produce varying values of SWF. The SWF values are, usually, the largest when the ultrasonic wave is transmitted along the fiber direction and the smallest when the wave is transmitted perpendicular to the fibers. The SWF values are also found to be dependent on the stacking sequence of the composite laminate. The application of this technique to composite materials will be discussed with particular attention given to the effects of fiber orientation on the information obtained.

MELT-SOLID INTERFACE DETERMINATION DURING A BRIDGMAN-STOCKBARGER CRYSTAL GROWTH. T. I. Ejim, W. A. Jesser*, A. L. Fripp.

The melt-solid interface positions during the solidification of Germanium, $Pb_{1-x}Sn_xTe$ and Silver using a Bridgman-Stockbarger furnace were determined by noting the discontinuity in the temperature gradient. Knowledge of these interface positions was used to determine the extent to which actual crystal growth rate deviated from the ampoule translation rate. It was found that for the semiconductors, Germanium and $Pb_{1-x}Sn_xTe$, there was no noticeable deviation between translation rate and growth rate. However, for the case of a metal, viz. Silver, the crystal growth rate was about 80% faster than the ampoule translation rate.

THE MAGNETIC PROPERTIES AND MICROSTRUCTURE OF PRASEODYMIUM-BASED AMORPHOUS MATERIALS*. G. C. Hadjipanayis*, S. H. Wollins*, R. C. Hazelton*, Kollmorgen Corp.; R. Prestipino*, K. R. Lawless, Dept. of Materials Science, Univ. of Va., Charlottesville, Va. 22901

Results of magnetic hysteresis and crystallization studies are reported for several $(Pr_{80}Ga_{20})_{100-x}Fe_x$ metallic glasses where $20 \leq x \leq 60$. Magnetic measurement are made in the temperature range of 4.2 - 1000 K and in magnetic fields up to 22 kOe. The crystallization behavior is examined by differential scanning calorimetry and transmission electron microscopy. Thermomagnetic measurements show two magnetic transitions around 470 and 870 K in $(Pr_{80}Ga_{20})_{70}Fe_{30}$. This is in addition to the low temperature transition reported[1] around 8 K. A relatively high coercivity (1 - 2 kOe) has been observed at room temperature in the x = 20, 30 metallic glasses but it disappears after crystallization. The onset of crystallization in $(Pr_{80}Ga_{20})_{70}Fe_{30}$ is found to be around 730 K. The effects of crystallization on the magnetization and coercivity will be discussed.

*Supported by ONR Contract No. N00014-81-C-0752

[1] S. G. Cornelison, D. J. Sellmyer and G. C. Hadjipanayis, J. Sppl. Phys. 52, 1823 (1981).

FRACTURE MODE INVESTIGATIONS OF He-IRRADIATED STAINLESS STEEL MICRO-SPECIMENS TENSILE TESTED IN AN HVEM. T. Hanamura and W. A. Jesser*. Dept. of Materials Science, Univ. of Va., Charlottesville, Va. 22901

By in-situ HVEM observations of fracture mechanisms in unirradiated and He-irradiated SS 316 specimens, using a video recorder, crack directions, α, and displacement vectors were measured during the crack propagations.

The unirradiated specimen tested at R. T. showed ductile transgranular fracture and frequent small oscillations of crack direction. The unirradiated specimen tested at 400° C showed the crack direction almost parallel to the tensile axis at the beginning of crack propagation which was in the thin region of the specimen and almost 45° in the thicker regions. The local ductility increased as the testing temperature increased. The annealed He-irradiated specimen tested at R. T. showed the crack direction of 45° in the thicker region, but the unannealed He-irradiated specimen showed a crack direction of nearly 90°. This result indicates that the ductility was increased by annealing after He-irradiation.

By measuring displacemtn vectors using the video recorder, %Mode I vs. crack direction α graphs were plotted. From this it was found that grain boundary sliding is initiated when a Mode I crack intersects a grain boundary at the appropriate orientation and can be suppressed by He-irradiation.

ANALYTICAL ELECTRON MICROSCOPY OF ALUMINUM ALLOYS. J. A. Hawk* and K. R. Lawless. Dept. of Materials Sci., Univ. of Va., Charlottesville, Va. 22901

Analytical electron microscopy (AEM) techniques were used to study precipitation adjacent to and on grain boundaries in both 2000 and 7000 series aluminum alloys. The techniques used included convergent beam electron diffraction (CBED), energy dispersive spectroscopy (EDS), scanning-transmission electron microscopy (STEM), and STEM convergent beam electron diffraction. These techniques helped characterize the precipitates on the grain boundary and showed whether precipitate free zones (PFZ) were formed during the heat treatment of the alloys. This information was used in determining the contribution of precipitation at grain boundaries on the stress corrosion cracking failure of the 2000 and 7000 series aluminum alloys.

THE EFFECT OF ALUMINA IN THE METHANOL SYNTHESIS CATALYST. P. Himelfarb and F. E. Wawner. Dept. of Materials Science, Univ. of Va., Charlottesville, Va. 22901

The effect of alumina on the microstructure in the copper/zinc oxide methanol synthesis catalyst has been investigated by transmission electron microscopy. The crystallite sizes and dispersions in the calcined catalyst - $CuO/ZnO/A\ell_2O_3$ and in the reduced (active) form - $Cu/ZnO/A\ell_2O_3$ are compared to the individual systems - CuO, Cu, $CuO/A\ell_2O_3$, $Cu/A\ell_2O_3$, ZnO, $ZnO/A\ell_2O_3$, CuO/ZnO, and Cu/ZnO. The increased catalytic activity of the alumina containing catalyst will be discussed in relation to these findings.

HYDROGEN EMBRITTLEMENT OF AISI 1018 STEEL AT VARYING CATHODIC CHARGING DENSITIES. Kathryn M. Hitchhock and M. R. Louthan, Jr., Virginia Polytechnic Institute, Blacksburg, Va. 24061

Cathodic charging of 1018 steel samples with hydrogen to saturation and subsequent tensile testing while charging results in an overall lowering of ultimate tensile strength and ductility. However as a cathodic charging current density is increased, the strain at fracture increased, leveling off at current densities greater than about 100 mA/cm^2. This surprising result indicates a saturation effect where for a limited increase in hydrogen concentration, ductility is not as severely impaired as at the lower charing densities. This must result from a hydrogen induced hardening and cracking of the metal lattice. Yield strengths and ultimate tensile strengths were not systematically affected by increasing current densities which suggests that the hardening did not play a major role in the increased ductility and therefore the change in microscopic elongation was attributed to cracking. Further support for the cracking effect was found from the observation that crack initiation was promoted by increasing current densities and occurred preferentially at the sample edges. This is attributed to test induced increases in the charging current densities at the samples edges where new, unprotected surface is continually being opened as tensile strains increase.

DAMAGE DEVELOPMENT IN FIBER-REINFORCED COMPOSITE MATERIALS.
R. D. Jamison. ESM Dept., VA Polytechnic Inst. & State Univ., Blacksburg, VA 24061-4899

The development of damage and ultimately the failure of fiber-reinforced composite materials involves a complex interaction of subcritical damage modes--fiber fracture, matrix cracking, interfacial debonding and delamination. The work reported here seeks to characterize this process for various lamination geometries of a T300/5208 graphite/epoxy material. A number of nondestructive and microscopic techniques are applied in a complementary manner to establish the modes and extent of damage at selected points in the life of specimens subjected to uniaxial tension-tension fatigue loading. Some modes of damage are shown to be consistent with the nature of the stress state predicted for such loading.

MICROSTRUCTURE OF SAMARIUM-COBALT MAGNET MATERIALS. K. R. Lawless. Dept. of Materials Science, Univ. of Va., Charlottesville, Va. 22901, and G. C. Hadjipanayis*, Industrial Drives Division, Kollmorgen Corporation, Radford, Va.

The microstructural features of a precipitation hardened $Sm(Co,Fe,Cu,Zr)_{7.22}$ magnet are examined using transmission electron microscopy and x-ray energy dispersive analysis. The ion-thinned samples were examined with a Philips 400 transmission electron microscope. The microstructure of a sample in the optimum state consists of a "cellular" structure in coexistence with a "lamellar" structure. The cells are approximately 1000 Å wide and the lamellae 30 Å thick. Lattice imaging shows that the cells have a 2:17 rhombohedral structure and that the thin lamella lie along (0001) planes. The effect of this microstructure on the magnetic properties will be examined.

MICROHARDNESS AS A MEASURE OF EMBRITTLEMENT OF LOW ALLOY STEELS. T.B. Meade and B. L. Shriver Dept. of Nuclear Engineering & Engineering Physics, Univ. of Va., Charlottesville, Va. 22901

The exposure of reactor pressure vessel steels to fast neutrons is known to result in reduced ductility and increased possibility of brittle failure. Therefore, it is desirable to develop accurate, nondestructive test methods for measuring the degree of embrittlement of pressure vessel steels.

Initial research at the University of Virginia and previous measurements indicate that the microhardness test can be used as a supplemental nondestructive measurement of embrittlement. Increases in microhardness with irradiation correlate with shifts in the ductile to brittle transition temperature. It appears that the microhardness test can provide a direct measurement of the actual transition temperature, irradiation induced shifts in transition temperature and in uppershelf fracture energy. The theoretical basis for these relations will be discussed.

USE OF COPPER BRAZING ALLOYS IN FRACTURE STUDIES. N. C. Pruitt and M. R. Louthan, Jr. Virginia Polytechnic Institute, Blacksburg, Va. 24061

Metallographic characterization of the progesses of fatigue, stress corrosion and overload fracture was improved when selected samples were immersed in molten copper-silver braze alloys prior to optical metallographic studies. The golden colored braze penetrated along both cracks and microfissures, because of the excellent wetting characteristics of the braze. This penetration was generally to the tips of metallographically sharp cracks. The gold color was easily observed, and the crack filling properties allowed for an excellent edge retention along the crack interface. Use of the braze alloy provided rapid determination of the surface connectivity of micropores and microcracks near the primary crack system. Such determinations showed that the majority of the metallographically observable micropores at crack tips of overload failures were connected to the primary crack surface even though ordinary metallographic observations (excluding serial sectioning) would indicate that the pores were not connected. This was not the case for secondary stress corrosion cracks which were frequently isolated from the primary crack surface. Such isolation is consistent with hydrogen embrittlement playing a role in the stress corrosion process.

THE PRIMARY ELECTRODEPOSITION OF GALLIUM. R. Paciej and G. E. Stoner* Dept. of Materials Sci., U. of Va., Charlottesville, Va., 22901.

The primary electrodeposition of gallium metal from low gallate ion concentration solutions has been studied. Bench scale experiments using high hydrogen overpotential cathodes were performed. The effect of hydrogen evolution inhibitors and varying pH on the current efficiency for plating has been studied using galvanostatic and potentiostatic electrolysis. Also, the effect on the current efficiency for plating during pulsed potential electrolysis has been observed for varying duty cycle, plating time and temperature, both above and below the melting point of gallium (T_M = 29.7° C).

IRRADIATION ENHANCED DECOMPOSITION OF A NI-C SOLID SOLUTION. R. E. Richardson and B. L. Shriver. Dept. of Nuclear Engineering & Engineering Physics. Univ. of Va., Charlottesville, Va. 22901

The effects of room temperature neutron irradiation and subsequent annealing on the properties of a nickel-0.3 wt.% carbon alloy were studied to provide information on the types of defect interactions within the solid solution. Such interactions may play a role in the reduced swelling observed in neutron irradiated nickel base metals with increasing carbon content.

The experiment involved microhardness measurements of carburized and uncarburized nickel samples following annealing between 200 and 1200°C. Tests were made on samples exposed to various fast neutron fluences (10^{17} to 4 x 10^{18} nvt) and unirradiated samples.

The data show two major effects. First, room temperature irradiation appears to reduce the mobility of carbon at temperatures below approximately 225°C. Second, irradiation enhanced the normal decomposition of the supersaturated nickel carbon solid solution which occurs between 225 and 600°C.

These results are interpreted in terms of interactions between carbon atoms and vacancies produced by irradiation. The results are consistent with the carbon-vacancy trapping model believed to be responsible for the reduced swelling found in Ni-C alloys.

EFFECTS OF GAMMA IRRADIATION ON THE STRENGTH OF KAPTON FILMS. C. D. Ross, B. L. Shriver Dept. of Nuclear Engineering & Engineering Physics, Univ. of Va. Charlottesville, VA 22901 and R. E. Barker Dept. of Materials Science, Univ. of Va. Charlottesville, VA 22901

This paper examines the effects of gamma irradiation on the mechanical properties and stress relaxation behavior of polyimides. Polyimides, a group of polymers exhibiting extremely high thermal stability, are widely used in printed circuit boards. Residual stresses can often buildup between the polyimide itself and the polymer substrate, leading to failure. It has been proposed that gamma irradiation of polyimides can induce stress relaxation, alleviating this mode of failure.

The present data indicate that the polyimides used for this study are slightly strengthened for gamma ray doses of up to 10^8 rads. The post irradiation stress relaxation rates are also increased by gamma irradiation.

THE MICROSTRUCTURE OF SiC MONOFILAMENTS. A. Y. Teng and F. E. Wawner*. Dept. of Materials Sci., Univ. of Va., Charlottesville, Va. 22901

Silicon carbide (SiC) monofilament is a potentially important fiber in composite systems. The fibers (SCS-2) are produced by chemical vapor deposition (CVD) on a carbon filament substrate. These filaments were etched and examined by SEM. The micrographs taken showed 2 distinct zones on the SiC bulk. The inner zone has smaller grains and was etched away faster than the outer zone. The grains were columnar in shape and oriented perpendicular to the surface. Further studies revealed the multi-layered nature of the SCS coating, and the presence of internal stress. (Funded by Fairchild Industries, Inc.)

HYDROGEN INDUCED CRACKING AT SURFACE DEFECTS AND INCLUSIONS. J. A. Wagner, M. R. Louthan, III, C. E. Kornegay and M. R. Louthan, Jr. Virginia Polytechnic Institute, Blacksburg, VA

The susceptibility of mild steel to embrittlement during disk pressure testing in gaseous hydrogen is a sensitive function of the pressurization rate, surface finish and inclusion or stringer morphology. Thin clamped disks (0.05 cm) of steel were tested to rupture in hydrogen and oxygen by slowly increasing the gas pressure on one side of the 10 cm diameter sample. The rupture pressure in hydrogen decreased as the pressurization rate and the roughness of the surface decreased. Neither variable had significant effects on the rupture pressure in oxygen. The hydrogen tested samples generally failed by leaking unless the pressurization rate was rapid; under rapid test conditions the samples burst at a pressure similar to that for oxygen tested samples and no embrittlement was observed. The hydrogen induced leaks developed by growth of surface flaws unless the surface finish was so smooth that inclusions served as failure initiation sites. Metallographic and fractographic observations demonstrated that the primilarily transgranular cracks which developed at the surface or internal defects grew without significant blunting and were oriented perpendicular to the plane of principal stresses.

THE FEASIBILITY OF PYROLITICALLY FORMED SiC FIBERS AS A REINFORCEMENT FOR METAL MATRIX COMPOSITES. W. J. Whatley and F. E. Wawner*. Materials Science Dept., Univ. of Va., Charlottesville, Va. 22901

A new type of SiC fiber which is formed by the pyrolytic degradation of polycarbosilane has recently come into focus as a possible reinforcement for Al matrix composites. In order to determine the feasibility of the use of such a material as a reinforcement some basic material properties must be known accurately. Among these are mechanical and microstructural properties, and how constant these are throughout the material. Results to be discussed include mechanical properties, preliminary results of microstructural determination, and interaction of the fiber with various alloys of Aluminum.

THE USE OF VIBROTHERMOGRAPHY FOR NDE OF COMPOSITES. S. S. Russell. ESM Dept., VA Polytechnic Inst. & State Univ., Blacksburg, VA 24061-4899

The term vibrothermography is used to describe a nondestructive testing technique where a portion of a structure's surface is mapped to indicate the temperatures on the surface while the structure is subjected to forced mechanical oscillations. Regions of imperfection may convert mechanical energy to heat through viscoelastic dissipation, collisions of internal free surfaces of a crack, or other mechanisms. Hence imperfections and defects may appear as hot regions when the surface is mapped to indicate the temperature.

Examples of the use of vibrothermography as a NDE technique in glass and graphite composite test coupons and machine parts will be presented.

KINETICS OF BUBBLE GROWTH UPON ANNEALING OF IRRADIATED THIN FOILS OF NICKEL. M. L. Sattler* and W. A. Jesser, Dept. of Materials Sci., Univ. of Va., Charlottesville, Va. 22901

The failure of first-wall materials in a fusion reactor is believed to be related to the growth of helium bubbles produced by the displacement damage of the helium flux in the plasma. Methods describing these kinetics include ripening events or migration and coalescence events. Furthermore, theories of migration and coalescence have been shown to follow power laws which can predict combinations of mechanisms, gas pressure behavior and rate-controlling processes.

The kinetics of bubble growth have been investigated on bulk materials that are thinned after irradiation to a predetermined dose and on He-preinjected thin samples that are subsequently annealed. The present experiments involve the annealing of physically vapor deposited nickel films with a small grain size, 200 nm thick, which had been irradiated by 1.0×10^{18} He ions/cm^2. The annealing was observed dynamically and the kinetics documented through measurement of bubble size and density, total swelling, and He density.

Results showed a general increase in bubble size with time. The few exceptions were bubbles growing adjacent to each other on the grain boundary where shrinkage of bubbles was observed. For the power law proportionality, $D \alpha t^n$, $n = \frac{1}{4}$ for bubbles growing on the grain boundary and $\frac{1}{2}$ for grain interior bubbles.

Medical Sciences Section

INSULIN STIMULATES THE INCORPORATION OF [^{3}H]-PROLINE INTO COLLAGEN AND NON-COLLAGEN PROTEINS IN CHONDROSARCOMA CHONDROCYTES, M.E.Bembenek and J.P.Liberti, Department of Biochemistry, Medical College of VA, Richmond, VA 23298.

Much recent work has centered on understanding the basic hormonal regulation of cartilage growth and development. The present studies were undertaken in an attempt to probe the effects of insulin on collagen production in freshly isolated chondrosarcoma chondrocytes. Cells ($1\text{-}4X10^5$/ml) were incubated with 2 μCi[^{3}H]-proline in the presence and absence of insulin. At the end of the reaction acid-precipitable material was treated with ultrapure collagenase to determine the amount [^{3}H]-collagen. Physiological concentrations of insulin increased ($p<0.01$) both collagenase-digestible material (CDM) and non-collagenase digestible protein (NCP). Half-maximal stimulation for both CDM and NCP occurred between 0.5 and .75 nM being 58% and 69%, respectively. Actinomycin D (10 μg /ml) completely blocked RNA synthesis, slightly depressed (∿30%) CDM production, and effectively suppressed (∿60%)NCP production. Insulin stimulated, in a concentration dependent fashion, both processes in the presence of Actinomycin D. Under these conditions, it appears that insulin stimulates collagen synthesis by both transcriptional and post-transcriptional mechanisms.

PRELIMINARY PROGRAMMING AND ANALYSIS VIA IBM 370 OF TAPED DATA DIGITIZED FROM SPECTROPHOTOMETRIC SCANS (186-650 nm) OF BLOOD PLASMA FROM STRESSED RATS ON LOW AND HIGH PROTEIN DIETS, R. W. Berlien,* G. Nunn,* S. S. Edwards,* and G. Colmano, VPI & SU, College of Veterinary Medicine, Blacksburg, VA 24061.

Two IBM System 370 computers (a 3032-under MVS and a 4341-under the CMS time-sharing system) allowed on-line storage with fast retrieval of a large quantity of data in this study. Spectrophotometric scans from blood plasma of rats (on 4%, 15%, and 40% protein diets and stressed at 36 days of age) were digitized using an Electronic Graphic Calculator interfaced with an HP2648A CRT. The x-y coordinates, using software control, were read into a data file on a CMS minidisk on the 4341 for temporary storage and easy access, and later transferred to a master file location on an MVS on-line storage disk in the 3032. Daily animal weights and food intake, adrenal and liver weights, and clinical determinations (ceruloplasmin, ascorbic acid, corticosterone, Lowry's protein, liver glycogen and hematocrit), using software control, were also entered into a master file location. The data manipulations are performed on SAS 79.5, operating under MVS, and the output (final results) can be routed for observation to a CMS minidisk. Development of our programs for statistical analysis of the data is in progress. Preliminary tests indicated that this system can be used for statistical analysis of rats, on high and low protein nutrition, and their response to stress.

POTENTIAL TRANSITION-STATE INHIBITORS OF GLYOXALASE I. R. B. Brandt, M.E. Brandt and M. April, Dept. of Biochemistry and MCV/VCU Cancer Center, Med. Col. of Va.(VCU), Richmond, VA 23298

A system which catalyses the formation of lactate from the dicarbonyl, methylglyoxal was reported early in this century. The formation of D-lactate is catalyzed by the mammalian enzymes, glyoxalase I (S-lactoyl-glutathione methylglyoxal-lyase, isomerizing) and glyoxalase II (S-2-hydroxyacylglutathione hydrolase), with glutathione (GSH) as a coenzyme. There have been reports on formation of methylglyoxal in mammalian tissue and experimental support for inhibition of tumor growth by inhibition of glyoxalase I has been published. The rapid catabolism of analogues of methylglyoxal or GSH suggest that inhibitors that resemble the transition state may more effectively inhibit glyoxalase I. The transition state in the formation of S-lactoyl-glutathione may be an enediol. We report here the inhibition in vitro of human red blood cell glyoxalase I with a number of enediols. These include the following with the I_{50} in mM: 3,4-dihydroxy benzoic acid (0.32), 3,4-dihydroxy benzohydroxamic acid (0.38), and 6,7-dihydroxy coumarin (0.03). Calculations based on the in vitro data and these structures may be predictive of their growth inhibitory capabilities. (Supported by funds from NFCR.)

RESPONSE TO IMMOBILIZATION AND NOISE STRESS ON RATS ON LOW AND HIGH PROTEIN DIETS, G. Colmano, S. S. Edwards,* and R. W. Berlien,* VPI & SU, College of Veterinary Medicine, Blacksburg, VA 24061.

Rats, 21-day old, pair-fed in 4 sets of 12 (4 each on 4%, 15%, 40% prot.) were equilibrated one week. Then, keeping sets 1 and 2 as controls, at 36 days (for 5 days) set 3 was stressed with restraint and set 4 with noise. The animals were orbitally bled at an age of 21, 28, 36, 41, and 46 days when they were decapitated. Absorption spectra (650-186 nm) of orbital blood plasma characterized dipeptide bonds at 190 nm, aromatic aminoacids at 278 nm, and hemoproteins at 414 nm. Decapitation blood was analyzed for ceruloplasmin, ascorbic acid, corticosterone, protein retention efficiency, Lowry's protein, adrenal weights, liver glycogen, and hematocrit. All data: digitized spectral absorbances, daily animal weights and food intake, and also the data from clinical determinations, were entered into an IBM 370 for statistical analysis. The preliminary data so far calculated indicate that low and high protein levels differed mostly in the hemoprotein and ceruloplasmin levels, which are stress indicators. To assess the effects of high and low protein nutrition and stress on infection, at 41 days sets 2, 3, and 4 will be later infected by bacteria and then viruses. This experiment will be then repeated for meaningful analysis of levels of protein nutrition, stress, and infection interaction.

TEMPERATURE DEPENDENCY OF TESTICULAR CHOLESTERYL ESTER HYDROLASE IN THE RAT TESTIS. L.A.Durham,III and W.M.Grogan. Med. Col. of Va.,Va. Commonwealth Univ.,Richmond, Va. 23298.

Cholesteryl ester hydrolase(CEH) was measured in 105,000xg. supernatant of rat and mouse testis and livers at various temperatures from 27-44°C. CEH of rat testis declined precipitously from 86±1(nmoles 4-^{14}C cholesteryl oleate hydrolyzed/hour/mg protein) at 32°C, the rat scrotal temperature, to 34±3 at 37°C, the abdominal temperature. CEH remained relatively constant from 27-32°C and 37-44°C. CEH of mouse testis showed a similar pattern of temperature sensitivity. Temperature effects were independent of protein and substrate concentrations. Liver CEH of both species remained relatively constant over the range of 27-37°C. These results demonstrate atypicallability of a testicular CEH or some associated factor at temperatures above that of the scrotum and suggest a direct mechanism for impairment of spermatogenesis and associated changes in steroid metabolism seen with elevated testicular temperatures as, for example, in cryptorchidism.

ELECTRONMICROGRAPHS OF STAPHYLOCOCCUS AUREUS ON SILVER COATED SURGICAL IMPLANTS ACTIVATED BY GROWTH INHIBITING CURRENT, L. K. Fainter,* S. S. Edwards,* AND G. Colmano, VPI & SU, College of Veterinary Medicine, Blacksburg, VA 24061.

Silver (Ag) or stainless steel surgical electrodes coated with different Ag compounds were used in vitro in blood agar, with or without contamination by S. aureus and with or without positive or negative 12 μA/cm^2 direct current for one hour. Scanning electronmicroscopy of control, positive and negative current-treated pins and surrounding agar showed bacteria: 1) more on positive than negative current-treated stainless steel electrodes, and in negative than positive current-treated agar; 2) fewest on negative current-treated solid Ag electrode and agar, lodged in possible erythrocyte pits on positive current-treated agar, and deformed on positive electrode surface; 3) more on control and negative current-treated oxidized Ag electrodes and agar, and less on positive current-treated electrode and agar; 4) low on all Ag stearate-coated electrodes and agar (greatest on control), and swollen on negative current-treated electrode but not in corresponding agar; 5) lowest on positive current-treated Ag stearate monomolecular films-coated electrode and agar; 6) low on all Ag electroplated electrodes; 7) heavy on control Ag electroplated chlorided electrodes and agar and absent in pitted areas of positive current-treated electrode while heavy on agar and minimal on both negative current-treated electrode and agar.

ULTRASTRUCTURAL EVIDENCE FOR THE ACTIVE PARTICIPATION BY VASCULAR ENDOTHELIAL CELLS IN LEUCOCYTIC DIAPEDESIS. T.M. Harris, Dept. of Anatomy, Med. Col. of Va., Richmond, Va. 23298

Diapedisis, the emigration of leucocytes through the walls of blood vessels is one of the hall-marks of the inflammatory process. E-M Studies by Marchesi and Florey (1961) first demonstrated the passage of leucocytes through inter-endothelial gaps belived to be forcibly produced by the leucocyte. An opposing view was offered in E-M studies by Willimson and Grisham, also in 1961. They described an active role for the endothelial cell that included the formation of long processes that "engulfed" the leukocyte. Their interpretation never gained acceptance so that all current reviews of diapedesis essentially accept the Marchisi and Florey description.

Recent E-M studies in our laboratory of diapedesis from limbic post capillary venules in the rabbit, frequently show undistorted neutrophils migrating through large, non-constricting interendothelial spaces. While the boundaries consist of long cytoplasmic processes of the endothelial cells that conform to the contours of the neutrophils. Such a relationship can only be interpretated as an active role by the endothelial cell. It thus appears that there is a wide range of interaction between endothelial cells and leucocytes and that elements of both opposing views are probably correct.

Glycogen In The Regenerating Extensor Digitorum And Soleus Muscle Grafts Of The Rat. J. M. Kennedy*, F. S. F. Mong, J. L. Poland, Depts. of Physiology and Anatomy, Med. Col. of Va., Richmond, Va. 23298.

Morphological regeneration of skeletal muscle grafts has been previously reported. Revascularization and reinnervation as well as muscle fiber regeneration have been documented. Grafts also recover their mechanical characteristics, but with a reduced capacity for tension development. To better relate morphological regeneration with function and to strengthen the basis for clinical applications, a closer look must be taken at the biochemical machinery of regenerating muscle. Glycogen is an important stored energy substrate, supplying glucose residues for enzymatic consumption. The purpose of this project was to describe the restoration of glycogen concentrations in the graft. EDL and soleus muscles were transposed and reexamined at 3, 5, 7, 10, 15, 30, and 60 days postoperatively. At 3 and 5 days glycogen concentrations are low, (15 and 20% of controls respectively). At this point the revascularization is complete, while only the peripheral cells are in the myotube stage of development. By 10 days regeneration has proceeded to immature fibers and glycogen increases to approximately 50% of controls. The muscle fibers are reaching maturity by 30 days with glycogen peaking at 75% of controls. Future work will be done to determine utilization of glycogen and thus metabolic integrity of the regenerating graft.

THYROID HORMONE CONCENTRATIONS IN BLOOD OF FEMALE WHITE-TAILED DEER IN RELATION TO SEASON AND FOOD CONSUMPTION. V. E. Kopf,* P. F. Scanlon, R. L. Kirkpatrick, and F. C. Gwazdauskas. Dept. of Fisheries and Wildlife Sciences and Dairy Science, VPI & SU, Blacksburg, VA 24061.

White-tailed deer (Odocoileus virginianus) exhibit inherent seasonal changes in food intake and body weight. Circulating concentrations of thyroid hormones (thyroxine, T_4 and triiodothyronine, T_3) were investigated in female deer throughout the year and analyzed for possible association with these inherent seasonal rhythms. Female deer (2 year old) were divided into 2 groups (ad libitum fed and restricted to 70% ad libitum). Deer were bled and weighed at 14 day intervals after immobilization with xylazine HCl. Circulating concentrations of T_4 and T_3, and body weight were significantly ($p<0.001$) affected by time of year. T_4 and body weight were not significantly affected by food restriction. Triiodothyronine was significantly ($p<.002$) affected and was most closely associated with food intake throughout the year. Concentrations of T_3 appear to be associated with inherent patterns of food intake and body weight changes and was sensitive to imposed food restrictions. [Supported by the Pratt Animal Nutrition Foundation]

ISOLATION AND CHARACTERIZATION OF RENAL BRUSH BORDER AND BASAL LATERAL MEMBRANE VESICLES FROM HOG KIDNEY. Theresa R. Leverone* and David R. Bevan, Department of Biochemistry and Nutrition, Virginia Polytechnic Institute and State University, Blacksburg, VA. 24061.

The epithelial cell of the kidney proximal convoluted tubule, like that of the small intestine, consists of two distinct plasma membrane surfaces referred to as the brush border, or luminal surface, and the basolateral, or antiluminal surface. Once isolated, membrane vesicles formed from the kidney epithelial cell can serve as models for the study of heavy metal nephrotoxin interaction with the two different plasma membrane surfaces. For ideal comparison between the two membranes, the isolation procedure should be identical for both. This has been accomplished by other investigators using differential centrifugation followed by free-flow electrophoresis or sucrose density centrifugation. Utilizing the self-forming gradient capabilities of Percoll, we have developed a less cumbersome procedure to effect simultaneous isolation of brush border and basolateral membrane vesicles. Application of brush border vesicles obtained by this method to the study of effects of cadmium on glucose transport will also be discussed.

STUDIES ON ESSENTIAL AMINO ACIDS AND TUMOR GROWTH. S. McElhanon,* W.M.Y. Chan, A.M. Kaplan and W.L. Banks, Jr. Depts. of Biochemistry and Surgery and MCV/VCU Cancer Center, Med. Col. of Va. (VCU), Richmond, Va. 23298

The effect of varying the concentration of a single amino acid (AA) in the diet of C57/Bl mice bearing either Lewis Lung carcinoma (LL) or methylcholanthrene induced fibrosarcoma (MCA) was examined with respect to host and tumor growth interrelations. AA's tested were Ile, Leu, Val, Lys, Met, Thr, Trp, Phe or Tyr. Isonitrogenous and isocaloric synthetic AA diets containing 0, 10, 25, 50, 75 or 100% (Control) of the test AA were fed to mice inoculated with tumor cells. After 2 wks (LL) or 4 wks (MCA), the animals were killed and tumors excised and weighed. A ratio of tumor weight to host weight (TW/HW) was used to identify a differential effect of the test diet on the host and the tumor. The results showed that Tyr, being non-essential, did not affect either host or tumor growth in LL or MCA. In LL, the feeding of Val (0, 10 and 25%), Phe and Thr (0 and 10%), Met, Leu and Trp (only at 10%)and in MCA, the feeding of Trp (0 and 10%), Thr (0%) and Ile (10%) were all effective in reducing TW/HW when compared to their respective controls. Thus, each tumor model system responded uniquely when less than optimal levels of the specific essential amino acids were fed. (Supported by NIH grant CA 26532).

SIMULATION OF DYNAMIC PHYSIOLOGICAL SYSTEMS USING NETWORK THERMODYNAMICS. Donald C. Mikulecky. Dept. of Physiology, Med. Col. of Va., Richmond, VA 23298.

Network Thermodynamics is a formalism which uses the concepts of network theory to solve problems generated by thermodynamic and/or kinetic descriptions of systems (generally by simulation, for complex, highly organized, dynamic systems). It is particularly useful in Biology due to the organizational complexity in living systems. Network thermodynamic simulation now utilizes preexisting circuit simulation programs, such as NET2, SPICE2, and ASTEC. This provides a cheap and efficient way to achieve simulations on a digital computer which previously were best done by analog or hyrid computation due to the complexity of the systems being simulated. A variety of nonlinear, dynamic physiological systems has been successfully simulated including coupled flows through epithelial membranes, reaction diffusion systems (including those with multiple steady states), whole body pharmacokinetics and the cellular pharmacokinetics of anticancer agents, kidney and general microcirculation, active transport of calcium in the sarcoplasmic reticulum in muscle, and others. New insight into basic thermodynamic concepts is being obtained by looking at both classical and nonequilibrium thermodynamics from the perspective of network theory. Included are the proof of Onsager Reciprocity through Tellegen's Theorem, and the use of networks to generate Legendre transforms and other classical results.

EFFECT OF TESTOSTERONE ON THE CHANGES OF GLYCOGEN IN THE TRANSPLANTED LEVATOR ANI MUSCLE OF RATS. F.S.F. Mong and J. L. Poland, Departments of Anatomy and Physiology, Medical College of Virginia, Richmond, Va. 23298

Levator Ani(L.A.) of rats is a testosterone dependent muscle. This dependency is also in the regeneration of the muscle if it is traumatized. Since a skeletal muscle will degenerate and then regenerate when freely transplanted to an ectopic site, we studied the effect of testosterone on the changes of glycogen (energy sources of muscle) in transplanted L.A. muscles. Male Sprague-Dawley rats (120 gm.) were used and the extensor digitorum longus (EDL) and L.A. muscles were removed, switched to each other's muscle bed, and sutured to the tendon stumps left in situ. The animals were divided into normal, castrated, injected, and castrated & injected groups. Those injected groups were given a dosage of 2 mg testosterone propionate daily. Sixty days after surgery the transplanted muscles were removed, weighed and analyzed for glycogen concentration. The results show that the glycogen concentrations of transplanted L.A. remained unchanged among the 4 groups of animals. However, the total glycogen content was significantly increased in injected and decreased in castrated groups, due to the significant increase in weight of transplants in the former and decrease in the latter. Thus the testosterone induced changes of transplanted L.A. are due to factors other than glycogen concentrations.

A 24-MONTH RETROSPECTIVE STUDY OF PREHOSPITAL ADVANCED LIFE SUPPORT (ALS) IN A RURAL SETTING IN VIRGINIA. Samuel Standford, Gloucester Family Practice, Gloucester, VA 23061 and Herbert M. Austin*, Virginia Institute of Marine Science, Gloucester Point, VA 23062.

Recent focus on prehospital care has confirmed the effectiveness of Advanced Life Support (ALS) by rescue squads in reducing prehospital motality due to cardiac and trauma emergencies. Stabilization of the patient in the field with ALS, particularly in the rural setting, is far superior to the traditional "throw-and-go" which has characterized rural volunteer squads. Careful selection, monitoring, and in-service training of squad members by progressive medical staff in even small rural hospitals can develop a cadre of highly motivated volunteer squad members capable of providing definitive prehospital Advanced Life Support.

Microbiology Section

GROWTH OF NEISSERIA GONORRHOEAE ON MODIFIED TRYPTIC SOY BROTH. I.A. Akinrinmade and R.R. Weik. Dept. Life Sciences, Va. State Univ., Petersburg, Va. 23803.

Tryptic Soy Broth (Difco Laboratories, Detroit, MI) is a dehydrated complex medium formulated to support the growth of fastidious organisms including Neisseria gonorrhoeae. In our laboratory, the medium failed to support growth of N. gonorrhoeae from an inoculum of 1000 colony forming units at 37°C in 5-10% CO_2 incubator. However, when 0.05%(w/v) L-cystine, 0.5%(w/v) sodium sulfite, 0.1%(w/v) soluble starch, 0.25%(w/v) glucose, and 0.25%(w/v) NaCl were added, there was moderate growth. An initial optical density at 600nm was 0.03 which increased to 0.195 in 24 hrs. Turbidity measurement was correlated with quantitative viable count of 1×10^6 colony forming units (CFU) per ml initially which increased to 7.6×10^7 CFU/ml at 24 hrs. The autolytic tendency of Neisseria gonorrhoeae was reduced to minimal as evident by microscopic examination and Gram staining. In addition, the medium did not alter the conventional biochemical reactions of gonococci including glucose fermentation and the formation of indophenol oxidase. (Aided by St. Luke's Hospital, Richmond, Va.)

SOLUBILIZATION OF NAD-INDEPENDENT SORBITOL DEHYDROGENASE FROM MEMBRANES OF GLUCONOBACTER OXYDANS SUBSP. SUBOXYDANS. C. A. Baker and G. W. Claus, Microbiol. Sec., Dept. of Biology, Va. Polytech. Inst. and State Univ., Blacksburg, VA 24061.

Species of Gluconobacter have unusually high respiratory rates (3000µl O_2/mg dry wt/hr) resulting from the rapid, single-step oxidation of polyols by membrane bound, NAD-independent dehydrogenases. The exact function of these enzymes is not understood. We selected sorbitol dehydrogenase because of the industrial importance of sorbitol oxidation. Our goal is to study the regulation of this enzyme in Gluconobacter. As an initial step, we wished to isolate and partially characterize the enzyme. Other polyol dehydrogenases from Gluconobacter have been solubilized with Triton X-100, but our repeated attempts to solubilize sorbitol dehydrogenase with Triton resulted in loss of activity. Six other detergents were tried. Of these, only n-octyl-β-D-gluconopyranoside released active protein from membrane fractions. Using 0.01M PO_4 buffer at pH 6, we found increasing amounts of enzyme solubilized as the detergent concentration was increased from 0.5 to 2.0%. The 2% concentration released 22% of the total membrane protein and 75% of the sorbitol dehydrogenase activity. The solubilized enzyme was stable for 1-2 weeks at 4°C. This appears to be the first successful solubilization of this enzyme.

THE EFFECTS OF SUCROSE ON GROWTH AND PROTEIN SYNTHESIS IN ANABAENA AZOLLAE AND A. CYLINDRICA. C. M. Bernard and J. E. Wilson. Va. State Univ., Petersburg, Va. 23803

Sucrose at levels of 1.0, 2.5, 5.0, 10.0, 20.0, and 40.0mM does not increase growth or protein synthesis in either species in aerobic batch cultures. Sucrose is utilized by the cells. Cultivation of both species under nitrogen in dialysis cultures supplied with 1.0mM sucrose resulted in inhibition of both growth and protein synthesis in comparison with aerobic controls. This inhibition is much less for A. azollae than for A. cylindrica.

INTERLEUKIN 2 PRODUCTION AND UTILIZATION IN THE TUMOR-BEARING HOST. C. J. Burger and K. D. Elgert. Dept. of Biology, Virginia Polytechnic Institute and State University, Blacksburg, VA 24061.

Whole spleen cell production of Interleukin 2 (IL-2), a soluble T cell-derived lymphokine, decreased with increasing fibrosarcoma burden. When tumor-induced suppressor T cells were removed by taking advantage of the cells' ability to adhere to nylon wool, the remaining nonadherent tumor-bearing host (TBH) spleen cells were capable of IL-2 production. The presence of a tumor-induced suppressor population was confirmed by using the more precise method of anti-sera depletion of specific T cell subpopulations. The ability of TBH spleen cells to receive and subsequently respond to IL-2 was measured by adding purified IL-2 to various proliferative immunological assays. Although the addition of purified IL-2 induced TBH spleen cells to a higher level of blastogenesis, the response did not reach normal levels. When physical separation techniques were used, the remaining T cell fraction (depleted of suppressor cells and enriched for helper cells) was more responsive to the mitogenic properties of IL-2. Absorption studies showed that Con A-induced TBH spleen cells were not as receptive to the IL-2 signal as ligand-activated normal cells. (Supported by NIH Grant CA 25943 and a Whitehall Foundation Grant.)

THE EFFECT OF CHLORINE ON A SMALL DNA VIRUS. C. C. Churn*, R. C. Bates, and G. D. Boardman*. Departments of Civil Engineering and Biology, Virginia Polytechnic Institute and State University, Blacksburg, Virginia 24061.

The parvovirus H-1 was purified, suspended in a phosphate buffered saline at pH7, and treated with sodium hypochlorite. The reaction between the virus and chlorine was neutralized by adding sodium thiosulfate. Then, either the whole virion, the capsid proteins or the nucleic acid was subjected to analysis by density gradient centrifugation, gel electrophoresis, or electron microscopy. The sedimentation rate of the chlorine-treated virus decreased from 110S to 50S, indicating that the viral particles had become lighter than empty capsids. The chlorine also caused certain sites on the proteins to become highly reactive, facilitating the formation of higher molecular weight aggregates. Electron microscopy revealed that alterations in the protein had caused the capsid to open and release the DNA, which appeared as a tail-like structure of the virion. Agarose gel electrophoresis however, indicated that the single-stranded DNA remained undamaged and was still capable of in vitro replication. From these results it was concluded that the mechanism of inactivation of parvovirus H-1 by chlorine was initiated at the protein level and not at the nucleic acid.

INHIBITION OF HORSERADISH PEROXIDASE ACTIVITY BY SPECIFIC ANTIBODY WHEN ALTERNATE SUBSTRATES ARE USED. S.K. Clark, Jr.* and J.M. Conroy. Dept. of Biology, Microbiology Section, Va. Polytechnic Inst., Blacksburg, VA 24061.

Horseradish peroxidase (HRP) catalyzes the reduction of hydrogen peroxide with electrons from a diverse group of hydrogen donors. Previous studies demonstrated that rabbit antisera specific for HRP inhibit enzyme activity when the primary amine dianisidine is used as hydrogen donor. Antibody-mediated inhibition of peroxidase activity using other amines or alcohols as hydrogen donors is reported here. Maximum inhibition of enzyme activity by antisera from three rabbits was the same (75%,50% and 85% respectively) whether mesidine (a primary amine), dianisidine, or guaiacol (an aromatic alcohol) was used as hydrogen donor. However, with phenol as hydrogen donor, maximal inhibition of enzyme activity was 70% regardless of the antiserum used.

Benzhydroxamic acid (BHA) was used to determine that inhibition of HRP by antibody is not caused by exclusion of phenol from its enzyme binding site. BHA binds to HRP and yields a spectrophotometrically distinct enzyme complex. The addition of phenol to BHA-HRP mixtures reduced complex formation indicating that phenol and BHA compete for the same enzyme site. HRP maximally inhibited by anticatalytic antibodies retained an undiminished capacity to bind BHA.

NORMAL AND TUMOR-BEARING HOST SPLEEN CELL RESPONSIVENESS TO MACROPHAGE-DERIVED FACTORS. C. J. Denbow*, J. M. Conroy, and K. D. Elgert. Dept. of Biology, Virginia Polytechnic Inst. and State Univ., Blacksburg, VA 24061.

The mixed lymphocyte reaction (MLR) was used to assess the responsiveness of normal and tumor-bearing host (TBH) murine Lyt^+ T cell subsets to normal and TBH macrophage (MØ) supernatants. TBH MØ supernatant was less able to enhance T lymphocyte subset MLR proliferation than normal. Normal and TBH spleen cell Con A-induced proliferation was determined 24 hr following in vivo introduction of normal MØ supernatant. Although normal MØ supernatant had no effect on normal spleen cell blastogenesis, TBH spleen cells exhibited more than a 2-fold increase in responsiveness. Prostaglandin (PGE_2) levels in normal and TBH MØ supernatants were in the range of 10^{-9} - 10^{-10} M. PGE_2 was titrated in the MLR. Although normal and TBH T cell proliferation was inhibited by PGE_2 at levels comparable to those found in MØ supernatants, normal T lymphocytes were more susceptible to inhibition than were TBH. Flatbed isoelectric focusing was used to fractionate normal MØ supernatant. Fractionated MØ-derived factor(s) were tested for inhibitory or enhancing activity in the MLR. (Supported by NIH Grant CA 25943 and a Whitehall Foundation Grant.)

PROTEASE SECRETION BY PATHOGENIC ZYGOMYCETES. P. E. Giebel, M. Griffis and M. L. Yeatts. Department of Biology, Virginia Commonwealth University, Richmond, Virginia 23284

Strains of Rhizopus rhizopodiformis and Absidia corymbifera isolated from human infections were examined for extracellular protease production and the potential significance of these proteases in pathogenesis. Fungal growth was in broth shake culture and the broth was separated from the fungi by filtration and examined for protease activity. Non-specific protease activity was measured using Azocoll, chymotrypsin activity using benzoyl-L-tyrosine ethyl ester (BTEE) and N-glutaryl-L-phenylalanine-p-nitroanilide (GPNA), trypsin activity using p-toluenesulfonyl-L-arginine methyl ester (TAME) and N-α-benzoyl-DL-arginine-p-nitroanilide HCl (BAPA), collagenase using Azocoll and insoluble collagen, and elastase using elastin-orcein. All strains of Rhizopus and Absidia produced proteases with Rhizopus levels being 3-6-fold higher, and protease production was repressed by glucose. Disc-gel electrophoresis demonstrated a heterogeneous complex of enzymes with collagenase-, trypsin-, and chymotrypsin-like activities; elastase activity was not detected. Trypsin and chymotrypsin-like activities were the highest, with collagenase activity being low and not present during the later stages of growth. Supported by NIH Grant 1-R01-AM28244-01A1.

PURIFICATION OF CALMODULIN FROM PHYSARUM POLYCEPHALUM. Catherine T. Gilchrist[1] and Mira Pahlic[2], [1]Dept. of Biochemistry and Nutrition and [2]Dept. of Biology, Virginia Polytechnic Inst. and State Univ., Blacksburg, Va. 24061

Calmodulin from Physarum polycephalum was purified using a two-step procedure. The first step involved anion-exchange chromatography on DEAE Sephadex A-25 in presence of 6 M urea and 0.2 M KCl. Highly acidic proteins such as calmodulin bind under these conditions and can be eluted with 0.7 M KCl. After dialysis the sample was applied to a Phenothiazine affinity column in presence of Ca^{++}. A salt wash removed proteins that bound weakly to the column. Calmodulin was eluted with EGTA. SDS gels of the dialyzed sample showed one major band with a molecular weight of about 18,000 when compared to marker proteins. Two-dimensional gel electrophoresis revealed one major spot of isoelectric point 4.3 and a molecular weight of about 18,000. The purified preparation after addition of 5 mM Ca^{++} activated bovine 3'5'-cyclic nucleotide phosphodiesterase.

ZYGOMYCOSIS IN DIABETIC (STREPTOZOTOCIN-INDUCED) MICE. M. Griffis, P. E. Giebel and M. L. Yeatts. Department of Biology, Virginia Commonwealth University, Richmond, Virginia 23284.

Previous model systems for zygomycosis and diabetes have utilized alloxan to induce diabetes-ketosis in mice and rabbits. In this study streptozotocin (300-275 mg/kg body weight,i.p.) was used to induce diabetes-ketosis in C57BL/KsJ (++/++) mice; ketosis was detected 24-72 hours after streptozotocin injection. When ketotic the mice were infected with Rhizopus nigricans (isolated from the craniofacial are of a ketotic human patient in 1981) at concentrations of 10^7 and 10^8 spores via the intraperitoneal and intranasal routes. After death homogenates of the brain, heart, lung, liver, and kidney were examined for infection histologically and with Sabouraud-chloroamphenicol culture plates. Infection was present when cultures and histology demonstrated fungal hyphae or histological examination alone demonstrated fungal hyphae. Intraperitoneal-infected mice demonstrated high frequencies of infection in the liver and kidney, with lesser frequencies in the heart and lung and a very low frequency in brain. Intra-nasal infected mice demonstrated a high frequency of infection in the brain, with low frequencies in the lung, liver and kidney and no infection in the heart. In 30% of the cases the culture tests were negative for infection but histological examination demonstrated the presence of hyphae in the tissue. Non-diabetic infected mice and diabetic mice receiving saline demonstrated no infection. Supported by NIH Grant 1-R01-AM28244-01A1.

MULTIPLE FORMS OF ACTIN AND THYMIDINE KINASE IN PHYSARUM POLYCEPHALUM. Mira Pahlic and John J. Tyson, Dept. of Biology, Virginia Polytechnic Inst. and State Univ., Blacksburg, Va. 24061.

Four species of actin were purified and identified on two-dimensional gels. Their molecular weight was 43,000 with three isoelectric points near 4.7 and one at 5.1. The amino acid composition was very similar to that of rabbit actin. A modified amino acid, 3-methyl histidine, which is characteristic of actins was identified. All four species bound to a DNase I affinity column. The amino acid composition of the 4.7 species was very similar to that of the 5.1 species. All four forms were found in the nucleus as well as in the cytoplasm.

Five species of thymidine kinase were identified on isoelectric focussing gels by their characteristic activities. The activities of the four most acidic forms first appear about one hour before metaphase, peak in telophase and decline during the S phase. The most basic form is active at about the same level during the entire cell cycle.

CORYNEFORM BACTERIA IN THE LEAF CAVITY OF THE NITROGEN-FIXING AZOLLA FERN. M.J. Petro*, J.E. Gates, & R.W. Fisher*, Dept. of Biology, VCU, Richmond, VA 23284

Coryneform bacteria occur in the leaf cavities of the Azolla fern along with the nitrogen-fixing Anabaena azollae filaments. These bacteria are aerobic, non-motile, and are Gram-positive, although they become highly Gram-variable as the culture ages. Rod-shaped cells evidencing "snapping-division" are characteristic of young cultures, but cocci are formed in older cultures. This developmental pattern is typical of the genus Arthrobacter, a common coryneform bacterium. These bacteria have been found in all cultures of Azolla which we have studied thus far including some material fresh from a California rice field. A linear relationship appears to exist between numbers of these bacteria and fern leaf age. They are found in the youngest fern leaves and their numbers often exceed numbers of Anabaena azollae. Others have reported that aerobic bacteria can enhance N-fixation in free-living Anabaena by lowering oxygen tension and thereby allowing the O_2-labile nitrogenase enzyme to function. These bacteria may also carry out saprophytic activity in senescing leaves. (Supported by USDA Grant 5901-0410-9-0304-0)

THE EFFECTS OF FRUCTOSE ON GROWTH, PROTEIN SYNTHESIS AND SPORULATION IN ANABAENA VARIABILIS AND A. AZOLLAE. L. C. Reekes, S. M. Weik, P. J. McNerney and J. E. Wilson. Va. State Univ., Petersburg, Va. 23803.

Fructose supplied at levels of 1.0, 2.5, 5.0, 10.0, 20.0, and 40.0mM causes growth and protein synthesis to reach a maximum at an earlier time than controls do. Growth and protein synthesis overtakes and sometimes surpasses the treatments. These results are explainable since fructose treatment causes more rapid growth and utilization of nutrients leading to conditions unfavorable to further growth. When additional nutrients are added along with additional fructose, higher levels of both growth and protein synthesis are obtained. In dialysis culture fructose at 5mM leads to significantly higher levels of chlorophyll synthesis in A. variabilis. Sproulation is inhibited in dialysis cultures by 5mM fructose.

FISHER,RW, SK FISHER,& JE GATES. DEPARTMENT OF BIOLOGY. VIRGINIA COMMONWEALTH UNIVERSITY, RICHMOND, VIRGINIA 23284

"THE AZOLLA SYMBIOSIS- A NITROGEN-FIXING ASSOCIATION USEFUL IN AGRICULTURE" The Azolla system is a nitrogen-fixing association between a water fern and a cyanobacterium or blue-green alga. The genus is divided into two subgenera containing 6 living species. Rhizosperma contains A. pinnata(AP) and A. nilotica. Euazolla contains A. filiculoides(AF), A. microphylla(AM), A. mexicana(AX) and A. caroliniana(AC). The Azolla sporophyte is composed of a branching stem containing bilobed leaves. The ventral lobe is achlorophyllous and serves as a float, the dorsal lobe contains chlorophyll and a cavity of symbionts. The cyanobiont in the cavity is an Anabaena species which fixes enough nitrogen for the entire association. Because of its ability to fix nitrogen, the association is being used as a nitrogen-bio-fertilizer. It can fix greater than 100 Kg N/Ha/y and, therefore, can supply significant amounts of fixed nitrogen to the ecosystem. Part of our research program focuses on improving the association for agricultural use. We have developed methods to separate the association. We have used light stress treatments to generate cyanobacterial-free AF,AC,AX,&AP. We also have Anabaena isolates from AC,AP, AX,&AF. We are characterizing these fern and Anabaena isolates and have started reassociation studies. Support from USDA Grant 5901-0410-9-0304-0.

A REFINED ENDONUCLEASE RESTRICTION MAP OF BOVINE PARVOVIRUS DNA. L. D. Thompson*, P. R. Burd*, and R. C. Bates, Dept. of Biology, Va. Polytechnic Inst., Blacksburg, Va. 24061.

Bovine parvovirus (BPV) is a single stranded DNA virus with a genome of about 5500 nucleotides. When replicated in vitro to a double stranded form, it can be cleaved by sequence-specific restriction enzymes to yield fragments of defined size. These fragments can be sized and oriented to provide a map of the genome, indicating where, on the genome, cleavage takes place. Using our preliminary restriction map, the enzymes Bcl I, Xba I, and Xho I were analyzed to determine their cleavage sites to provide additional information about the BPV genome. A series of single and double digestions were utilized to yield fragments which could be oriented and compared to models constructed from possible predicted configurations, to give the actual cleavage sites on the genome. Bcl I yielded three fragments of 4050 base pairs (bp), 750 bp (3' end), and 690 bp (5' end). Xba I yielded two cleavage products of 4700 bp (5' end) and 775 bp (3' end). Xho I yielded three cleavage products of 4200 bp, 720 bp (3' end), and 650 bp (5' end). With this refined restriction map of BPV, it will be possible to more accurately analyze the genetic makeup of the virus.

ENFLAGELLATION OF NAEGLERIA FOWLERI:REGULATORY CHARACTERIZATIONS AND COMPARISONS. T.W. Woodworth, D.T. John*, and S.G. Bradley. Depts. of Microbiology, Va. Commonwealth Univ., Richmond, and *Oral Roberts Univ., Tulsa, OK.

Naegleria fowleri amebae differentiate into swimming flagellates when washed free of culture medium and suspended in nutrient-free ameba saline. N. fowleri enflagellation is more rapid and extensive when stationary phase cultures are suspended at a population density of $<5 \times 10^5$ amebae/ml. Neither growth phase or cell density are critical for N. gruberi enflagellation. Under optimized conditions, 65% of N. fowleri amebae enflagellated beginning ca. 90 min after subculture. Actinomycin D(25μg/ml) or cycloheximide(0.5μg/ml) inhibited enflagellation when added prior to 1 h after subculture and caused hastened reversion of flagellates at later times. An extensive complement of polypeptides was synthesized during enflagellation. Two-dimensional(2D) gel autoradiograms revealed that no limited number of species were made in exceptional abundance. Autoradiograms of 2D-gels of flagellates and growing amebae of N. fowleri were compared. Relatively few changes in pre-labeled proteins occured during enflagellation. Processes other than extensive de novo protein synthesis(e.g. covalent modifications, degradation, export) may be important in Naegleria enflagellation and may contribute to the apparent regulatory differences between the ultrastructurally similar differentiations of these two Naegleria species.

ANALYSIS OF PROTEIN CHANGES DURING THE CELL CYCLE OF PHYSARUM POLYCEPHALUM BY TWO-DIMENSIONAL GEL ELECTROPHORESIS. Mira Pahlic and John J. Tyson, Dept. of Biology, Virginia Polytechnic Inst. and State Univ., Blacksburg, Va. 24061

Nuclear division, DNA synthesis and other periodic events of the cell cycle occur synchronously in the large, multinucleate plasmodia of the acellular slime mold Physarum polycephalum. To study periodic changes in protein synthesis, modification and breakdown during the cell cycle in Physarum, we have begun a survey of the 1000 + proteins that can be resolved on two-dimensional gel electrophoretograms. The gels are prepared from total extracts of plasmodia harvested at various stages in the cell cycle, then they are stained with a sensitive silver stain and photographed. The B/W negative is digitized, and the digital image is processed by the General Image Processing System (GIPSY) developed by R. H. Haralick and coworkers at VPI & SU. The computer analysis system will be described in some detail, and the results of a preliminary survey of the cell cycle will be presented. At present we have found one protein that shows significant, reproducible fluctuations in total amount during the cell cycle.

MICROBIAL TRANSFORMATIONS OF ZINC SULFATE IN OXIDIZED AND REDUCED SEDIMENTS
Sung Ok Yoon and S.G. Hornor, Dept. of Biology, VPI & SU, Blacksburg, Va. 24061

Transformations of zinc sulfate mediated by sulfate reducing bacteria were investigated in sealed microcosms consisting of sediment and water from a mountain stream. These systems were amended with $ZnSO_4$ in the presence and absence of a readily degradable carbon source, cellulose. Concentrations of SO_4, CO_2 and dissolved oxygen were measured according to standard methods. Free and bound sulfides were measured by gas chromatography following acidification; zinc levels were determined by atomic absorption spectroscopy. Microcosms containing reduced sediments, as evidenced by negative Eh values, showed substantial microbiological reduction of SO_4, production of CO_2 and sulfide. Concentrations of ZnS within these sediments were correlated with sulfide evolution. In contrast, microcosms containing more oxidized sediments, i.e., those not amended with cellulose, showed significantly lower levles of SO_4 reduction and ZnS accululation. The increased concentrations of zinc sulfide in reduced sediments suggest that microbial sulfide production enhanced the formation of insoluble zinc sulfide which was precipitated into the sediment in a form no longer available to aquatic biota.

Psychology Section

EFFECTS OF PRIOR APPETITIVE PARTIAL AND CONTINUOUS REINFORCEMENT ON SELF-PUNITIVE BEHAVIOR IN THE RAT. E. H. Artz III*, Dept. of Psychology, Washington and Lee Univ. Lexington, VA 24450

Previous research in the area of self punishment has investigated the effects of certain variables, such as shock intensity, discriminative cues, and location of the shock area, which have potent effects on self punishment. In the present study, attention was given to the effect of the organism's prior appetitive reinforcement history on subsequent self-punitive behavior. Initially, rats were trained in an operant conditioning chamber under partial or continuous appetitive reinforcement schedules. Shock-escape training in a runway followed. Prior to non-shock or self-punitive extinction testing in the runway, each animal underwent 5 min. of appetitive extinction in the operant chamber. Analysis of running times during escape extinction indicated self-punitive behavior. Moreover, the animals who had previously received partial appetitive reinforcement showed markedly greater resistance to escape extinction than did the animals who had received continuous appetitive reinforcement.

A STUDY OF THE SOCIAL DESIRABILITY OF ITEMS ON AN EMPLOYMENT EVALUATION FORM. L. W. Baldwin,* and A. V. Harris, Department of Psychology, Radford University, Radford, Virginia. 24142

Research has indicated that the probability of endorsement of an item or trait increases with the items judged desirability. This experiment examines the social desirability of items on an employment performance evaluation form, and the possible sex-related differences, using the survey method, administered to college students.

The results showed that males felt that productivity was more important and socially desirable than females did. Females rated adaptability significantly higher than males did. The traits or characteristics of establishing good relationships and dependability were ranked highest in social desirability by approximately 50% of the subjects. Safety consideration was ranked lowest in social desirability by approximately 50% of the subjects.

The implications of this work are discussed.

INVESTIGATIONS OF HUMAN JEOPARDY WITH THE USE AND ABUSE OF "LIE DETECTORS IN COUNSELING AND PSYCHOTHERAPY. John C. Bartone. American Health Research Institute, Ltd. Annandale, Virginia 22003.

The art and science, as well as uses and abuses of "lie detectors" is still being ignored by science and medicine. The widespread use of lie detectors of various sorts now has spread into psychotherapy and counseling. Validity and reliability given to lie detectors is excessive and usually applied by commercial entrepreneurs. Placing great validity upon any form of lie detector is unscientific and not warranted. Scientific investigations and analytic interrogations of personality, behavior, crime or morality are multiform processes in which the "lie detector" is only one facet. Today lie detectors are given great credence with such operators creating additional problems in societal interactions. Cases are presented to reveal erroneous use and reliability upon such devices which ruined lives of the involved.

THE EFFECTS OF UNILATERAL ENTORHINAL CORTICAL LESIONS ON SPATIAL AND CUE TASKS IN THE RAT. James H. Campbell* AND K.W. Johnstone.* Dept. of Psychology, Washington and Lee University, Lexington, VA 24450. (Sponsor: L.E. Jarrard)

Recent studies in our lab using bilateral entorhinal cortical (EC) lesions on rats have shown a significant impairment of performance on complex spatial (place) and cue tasks. Rats, for the spatial task, were trained to visit 4 out of 8 arms on a radial maze, and for the cue task, were trained to choose 4 out of 8 arms containing inserts wihch were moved from trial to trial. All rats were trained on both tasks. In the present study, 8 rats were trained on the complex tasks described above. 4 rats received unilateral EC lesions, and 4 served as unoperated controls. Following 3 days postoperative recovery, all rats were retested for 11 days on both tasks. No significant behavioral changes were observed. Past studies have shown in some cases that impairment following serial lesions was less than that following bilateral lesions. 14 days following the first operation, the contralateral EC of the experimental animals was lesioned. Initial data, after 4 days of testing shows significant impairment on both spatial and cue tasks. Comparisons between the effects of serial and bilateral EC lesions will be discussed.

THE INFLUENCE OF TOUCH ON VISUAL BEHAVIOR: THE DESIRE TO CONTROL AS MEDIATOR. Teresa W. Caudill*, Old Dominion Univ., Norfolk, VA 23508

Past studies on the effects of touch have focused primarily on (1) evaluations of and liking for the person who touches and (2) compliance to requests following touch. However, evaluations of the toucher's personality are susceptible to social desirability effects, and compliance may occur in the same manner but because of very different motives (to obey, to do a favor, to quickly escape the situation, etc.). Behavioral responses in the form of nonverbal behaviors are useful because such responses to touch are relatively unaffected by social desirability and not easily censored. Visual behavior was chosen as the nonverbal measure because of the wealth of research that has been done to date, and because of its documented sensitivity to changes (particularly power-oriented changes) which occur within dyads. This experiment investigated the influence of touch upon the visual behavior of females as a function of the recipients' levels of desire to control others. Also measured were the recipients' evaluations of and liking for the confederates, as well as mood and affect, following the touch. Subjects were 24 females scoring high and 24 females scoring low on the desire to control others, as measured by the Expressed Control subscale of Schutz's (1958) FIRO-B personality inventory. Half of all subjects were touched by one of the three male confederates after 2 minutes of the 4-minute interview.

SPORT PSYCHOLOGY: APPLICATIONS OF BEHAVIORAL SCIENCE TO IMPROVE TENNIS PERFORMANCE. Liza Davis*, Tanya Sullivan*, Leslie Perlman*, and E. Scott Geller, Sponsor, Dept of Psychology, VPI & SU, Blacksburg, VA 24060.

Under the supervision of Dr. Scott Geller, a research project was implemented which focused on psychological approaches for improving tennis performance. The subjects (who were lab assistants) met at the local park each day. For each subject two responses were chosen from the forehand tennis stroke to be used as problem target areas. The two areas were chosen from the following: 1) bending of the knees; 2) follow-through; and 3) keeping the back foot stationary.

Each day standard coaching was implemented. This included basic instruction and modeling by a tennis instructor. Dr. Geller stood at the net and tossed the subjects tennis balls. Ten strokes consisted of one session. The subjects were rotated through as many sessions as time would allow. For the different target areas different treatment techniques were tried. These consisted of awareness, feedback, and probing. At each session there were two to three observers, observing independently of each other. It was found that probing and feedback may have a positive (sometimes transient) effect on the target areas. However, future research is needed in this area, and the presentation suggests certain methodologies, interventions and empirical questions.

FURTHER STUDIES ON AFFECT AND REPETITION IN MEMORY. Craig Dye* and David G. Elmes. Dept. of Psychology, Washington and Lee Univ., Lexington, VA 24450

In Experiment 1 the finding that massed-practice items receive lower affective judgments than distributed-practice ones was replicated using a list having several distributed repetition intervals. Contrary to what was expected in Experiment 2, having subjects generate positive images to neutral words did not eliminate the spacing effect as happens when words of positive connotation are recalled. The third experiment showed that connotative evaluation of neutral words was similar for recalled and non-recalled words across spacing intervals. These puzzling results suggest that the affective and cognitive components of the memory trace both promote recall but independently of each other.

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RELAXATION AS A HEALTH PROMOTION STRATEGY. A. Friedman*, S. Lovett*, A.W. Riley* Dept. of Psychology, Va. Polytechnic Inst., Blacksburg, Va. 24061.

The effects of social support were investigated within the context of a hospital-based community health promotion program. A state of the art program in relaxation techniques was offered free of charge to the community. Participants were encouraged in program announcements to attend with a friend or family member. Approximately 70% of the participants attended the program with another person. A significantly greater number of the individuals with social support successfully completed the program. Individuals who adhered to the program reported a significant reduction in stress related physical problems at post-test.

These results suggest the efficacy of utilizing established social ties to improve adherence to community health promotion programs. Participants are readily encouraged to attend with a friend or family member and this shared committment can have a significant impact on program involvement. Further, such involvement in a relaxation program has a significant effect in reducing self-reported physical symptoms of stress.

THE DANGERS OF EYE WITNESS TESTIMONY. Laura Gibowski and A. V. Harris, Department of Psychology, Radford University, Radford, Virginia 24142.

One-hundred and twenty-five Radford University students, when asked to respond as jurors to hypothetical crimes, rated the reliability of witnesses and their testimonies under varied conditions. In violent crimes, females more often choose the witness not having the auditory impairment than males, in terms of reliability of their testimony. Overall, females found variables such as alcoholism, past record of extortion, and auditory impairments to have a greater detrimental effect on the validity of the eye witness testimony. Generally these variables appeared more detrimental to the character of witnesses of violent crimes rather than nonviolent crimes. These findings agree with Elizabeth Loftus who found females to be more affected by violent situations than males, as witnesses.

SELF-STARVATION AND STRESS-INDUCED ANALGESIA. James L. Hughes.* Old Dominion Univ., Norfolk, VA 23508

Juvenile rats were placed on a 23-hour food deprivation schedule and confined to activity wheels after adaptation to deprivation. They and their food-yoked controls were tested pre- and post-feeding, using the tail-flick method of pain threshold measurement, in an attempt to explore the hypothesis that the combined stressors of deprivation and hyperactivity elicited by this paradigm would result in elevated levels of endorphins and subsequent analgesia. The expected hyperactivity was not observed due to the developmental level of the subjects, and no difference was found in pain threshold between groups or pre- and post-feeding conditions. Discussed was the use in this study of a without-heat source condition in the pain threshold testing, and its usefulness both as a measure of general arousal level and as a control for the confound of arousal level in pain threshold testing.

STRESS MANAGEMENT FOR ORGANIZATIONS IN TRANSITION D. W. Gilley*, and B. Bennett*. Dept of Psychology, VPI&SU, Blacksburg, Va. 24060.

Transition periods in organizations (e.g. change of goals, structure, physical environment) is a potent environmental stressor. A program was developed to aid nonadministrative organization members in dealing with this source of stress. The 6-session program provided information about stress, relaxation training, cognitive restructuring, and self-control techniques in a group format and self-study manual. A pilot study of the program was conducted with students and laboratory technicians in a rapidly expanding school of veterinary medicine. Subjects were randomly assigned to treatment (n=9) or no treatment measurement control (n=10) groups. At pre-test one week before the delivery of the program, the groups were similar in perceived aversiveness of the work environment, trait anxiety, frequency and intensity of physical symptoms associated with stress, quantity and quality of daily work performance, health locus of control, and rationality of general beliefs. At post-test one week after the program, participation was associated with reliable declines in trait anxiety and in the frequency of reported physical symptoms. Changes in the expected direction were also obtained on other outcome measures, but these differences did not reach statistical significance.

THE EFFECT OF LITHIUM ON COMPLEX SPATIAL AND CUE MAZE LEARNING IN THE RAT. David J. Hepler.* Dept. of Psychology, Washington and Lee University, Lexington, VA 24450 (Sponsor: L. E. Jarrard)

Recent research has suggested that lithium may facilitate learning in the rat. Lithium toxicity, however, has created a formidable methodological problem for researchers in this area. The effect of lithium on activity, eating, and drinking was continuously monitored by a computer system. Daily i.p. injections of 1.4 mEq/Kg lithium chloride did not affect home cage activity levels and caused only minor changes in eating and drinking behavior. In the learning study, experimental animals were injected daily with this same dosage, while a control group received saline. Both groups were trained to run to four baited alleys of an eight arm radial maze in two learning conditions (spatial and cue). After this task had been learned, the animals received reversal training where the previously unbaited alleys were baited. Results indicated that there were no significant differences between experimental and control groups for either working or reference memory errors incurred in the maze acquisition and reversal tasks (in both spatial and cue conditions). However, running time was significantly increased for lithium animals. These findings will be discussed as they relate to current theories of lithium action.

PERCEPTION OF INFANT CRIES: AN ANALYSIS OF THE EFFECTS OF METHODOLOGY. L. Huntington*, P. S. Zeskind*, K. E. Pocius*, Dept. of Psychology, Va. Polytechnic Inst. Blacksburg, Va. 24060

Newborn infants may be "at risk" for developmental problems due to a number of prenatal and perinatal factors. The infant's cry may reflect the amount of effect that any complications have had on that particular infant. The cry may also reflect the biological condition of the infant, and may affect the quality of care that the infant gets. Several studies have investigated the differences between the cries of healthy infants and those of infants considered at risk because of complications. Perception studies have shown that the cries of at-risk infants tend to be rated more "aversive", "sick", and "urgent" than the healthy infants' cries. These studies have been done using within-subjects comparisons, so that all subjects heard both types of cries. The current study was performed to investigate the effect of these comparisons on the subjects' judgements. Subjects Were first exposed to cries of only one type (healthy or at-risk). The subjects then heard a series of cries in which the two types were mixed. The results of this study show that the cries of the at-risk infants were percieved as more "aversive", etc., than the cries of the healthy infants. The differences in the ratings of the cries were larger after the subjects had the mixed-cry series than when rating only one type of cry.

THE RELATIONSHIP BETWEEN SOCIAL ADJUSTMENT AND LEARNING DIFFICULTIES AMONG COLLEGE STUDENTS. P. A. Jarvis*, and E. M. Justice*. Department of Psychology, Old Dominion University, Norfolk, VA 23508

The social adjustment of college students with learning problems was compared to that of students without learning difficulties. Group I students, drawn from remedial writing classes, were experiencing learning difficulties, while Group II students, drawn from Freshman English composition classes, were experiencing no significant learning problems.

All subjects were administered (a) The Tennessee Self-Concept Scale, (b) The Self-Concept as a Learner Scale, and (c) The Is of Identity Test (IOI) to measure social adjustment.

Results indicated that students with learning problems scored significantly lower on measures of self-concept than their peers with no learning difficulties. While there was no significant difference in social adjustment, as measured by the IOI, Group I scored significantly lower on the Tennessee Self-Concept Scale and on the class membership subscale of the Self-Concept as a Learner Scale. These data suggest that learning problems have implications for the social, as well as academic, adjustment of college students.

STRESS AND PRODUCTIVITY. S. Q. Love*, A. Riley*, B. Bennett*, T. Bowers*. Dept. of Psychology, Va. Polytechnic Inst. and State Univs., Blacksburg, Va. 24061

The project investigated the effectiveness of a time-limited stress management package with a population of hourly employees and first line supervisors of a health insurance company serving Southwest Va. (n=83). The program used a two group, waiting list control design and had a cognitive/behavioral orientation including components such as analysis of stress via self-monitoring, relaxation training, assertiveness training and use of social support. Dependent measures were a life events checklist, trait anxiety, social support, perceived work environment, health care utilization, absenteeism, and productivity. Subjects developed a more positive view of their job, used more social support, and reported lower levels of anxiety on the daily measure. These results varied to some extent by workplace in the organization. However, the program did not result in an overall immediate improvement in productivity, health measure, or job satisfaction. Results were discussed in terms of the need for additional work in the area of stress management, organizations, and organizational change.

AN INDUSTRY-BASED PROGRAM TO ENCOURAGE SEAT-BELT USE: HOURLY VS. SALARY EMPLOYEES. Lisa Paterson*, Liza Davis*, Lisa Keeton*, and E. Scott Geller, Sponsor, Dept of Psychology, VPI & SU, Blacksburg, VA 24060.

An incentive program for motivating seat belt use was implemented at four industrial complexes in Southwest VA. Seat belt use was assessed twice daily at each plant parking lot as employees arrived for work in the morning and departed in the afternoon. The incentive program, which consisted of distributing fliers enabling seat belt wearers the opportunity to win prizes, was only in effect during the morning or afternoon at any plant. This design provided measurements of response maintenance and stimulus generalization.

Of the plants, the incentive program had its greatest effect at a large army ammunition plant which had previously promoted safety practices to a large extent. At this plant, seat belt wearing increased from 18.5 percent during pre-treatment to 57% during incentive distribution. For two other plants, the incentive program produced a differential effect when seat belt use of Salary and Hourly workers was compared. That is, incentives had a minimal influence over hourly workers, whereas salary workers showed marked increases in seat belt wearing.

Follow up data obtained at each industry revealed that seat belt wearing decreased when incentives were not being distributed, but did not reach the low usage levels observed during pre-treatment baseline.

INTERNAL-EXTERNAL LOCUS OF CONTROL AMONG MEMBERS OF ALCOHOLICS ANONYMOUS. Christine Philput. Dept. of Psychology, Old Dominion University, Norfolk, Va. 23508.

This study is undertaken to examine locus of control (internality-externality) in recovering members of Alcoholics Anonymous (AA). Variables that might affect locus of control, such as sex, age, profession, previous psychiatric treatment, and length of membership in AA are also examined. Twenty-four members of an AA home group took the 24-item Levenson IPC scale (with 3 factors, Internality, Powerful Others, and Chance), and a one page questionnaire covering the variables of interest. After six months, these same subjects will be retested with the previously mentioned measures.

Results of the first testing session reveal that AA members score similarly to normals on the Powerful Others factor, similarly to neurotics and depressives on the Chance factor, but more externally than the normal or psychiatric samples. Correlations are computed for each variable of interest and each of the IPC factors. These results are somewhat contradictory to those obtained from alcoholics with the Rotter I-E scale.

THE EFFECT OF MARKER SCENES ON THE RELIABILITY OF SCENIC QUALITY RATINGS. Michael R. Patsfall* and Nicholaus R. Feimer. VPI & SU, Blacksburg, VA 24060

Research concerning the reliability of scenic quality and visual impact assessment (SQVIA) ratings indicates that when a small number of raters (five or less) is used, the reliability of ratings tends to be unacceptably low. Since the use of five or less raters for a particular SQVIA problem is prevalent in applied settings, the reliability of ratings is an important concern. The lack of consistency in SQVIA judgments may be due to the (1) ambiguity of criteria used for making judgments, and (2) the complexity of the judgment task. A solution is the use of marker scenes, which are reliably scaled visual stimuli anchoring the points on a rating scale. In the current study, three subsamples of college students each rated one of three sets of 107 western U.S. landscape scenes using a five point scenic beauty rating scale. The method of successive intervals was then used to derive a scale of scenic beauty, and five marker scenes were selected to represent five equivalent points along the continuum. Two groups rated 30 scenes with one group using the marker scenes as the basis of their judgments and the other group using only implicit criteria. Results are discussed in terms of the incremental utility of the marker scene approach, future research needs, and implications for management implementation of the marker scene approach.

WOMEN AND MEN IN MALE DOMINATED PROFESSIONS AND OCCUPATIONAL PRESTIGE. Michele Terranova.* Old Dominion Univ., Norfolk, VA 23508

This study examined the attitudes of men and women in a traditional male occupation towards other females entering a similar male-dominated occupation. Engineering majors returned questionnaires that included a job profile of architects and questions regarding the prestige and desirability of that occupation. The profiles appeared in two different forms, one which predicted future female proportions to remain stable at 10 percent and the other predicted an increase to 30 percent, for a control and experimental group respectively. Subjects also completed an attainment scale for work goals and an attitude scale toward work and sex roles. There was a significant difference between male and female scores on a sex role statement. Women strongly disagreed that their careers should be secondary to their husbands' if a conflict arose between the two. The general homogeneity of the results between the two sexes led the author to conclude that students within the same occupation exhibit similar goals in work attainment and sex role attitudes, and neither group devalued an occupation as a result of an increased proportion of females.

IMAGERY AND THE RELEASE FROM PROACTIVE INTERFERENCE IN SHORT-TERM MEMORY. R. H. Stall* Washington and Lee Univ., Lexington, VA 24450

Word or picture triads were presented in the Wickens paradigm with a different triad presented on each trial. Control subjects were presented with one type of stimulus, while the experimental groups experienced a shift to the opposing class (words then pictures or vice versa) on the fourth trial. Release from proactive interference for both experimental groups occurred, but the word to picture group showed a greater amount of release than did the picture to word group. These results seem to show the presence of two distinct short-term memory information stores and that pictorial information is encoded dually to a greater degree than is verbal information.

SCRAP EVERY SUNDAY: BEHAVIORAL ANALYSIS OF A CHURCH-CENTERED ALUMINUM RECYCLING PROGRAM. C.W. Moore* and E. Scott Geller. Dept. of Psychology, Va. Polytechnic Inst. and State Univ., Blacksburg, Va. 24060.

Local churches can become centers for recycling household aluminum scrap in significant quantity by relating a recycling program to an established program of the church. Fifty-nine churches of the Fincastle Presbytery (a unit of the Presbyterian Church in the United States) were urged to ask their members to make weekly collections of household aluminum scrap to be brought to a collection box in the church every Sunday. The scrap was sold each week to a recycling center and the proceeds contributed to the Presbytery's "Halt Hunger" program. Churches received weekly reports of the amount and value of scrap collected.

Seventeen churches entered the project and continued it for three months or more. Weekly reports to individual members had no effect on the amount of scrap collected. A total of 2,805 pounds of aluminum scrap was collected over the first nine months of the project, and sold for a total of $561.23. Volunteers provided all labor and transportation.

ADULT PSYCHOPHYSIOLOGICAL RESPONSES TO CRIES OF LOW- AND HIGH-RISK INFANTS. K. E. Pocius*, P. S. Zeskind*, and L. Huntington*. Dept. of Psychology, Va. Polytechnic Inst., Blacksburg, Va. 24061

Pre- and perinatal complications have been shown to affect the physical, intellectual and behavioral functions of the infant in later development, thus placing the infant at risk. Although many infants with these nonoptimal obstetric conditions develop into normal healthy infants, the effects of these earlier complications may be reflected in the behavior of the infant. This behavior in turn may be perceived by the caregiver as having certain demand characteristics. Crying, a particularly salient behavioral characteristic of the infant, has been implicated in the perception by caregivers of the presence of these demand characteristics. Heart rate responses of twenty male and female college students were measured while listening to a tape recording of pain cries elicited from 2-day-old normal healthy infants. Half of the cries were from low-risk infants and half of the cries were from high-risk infants. Heart rate changes among males were found to be greater to cries from high-risk infants than low-risk infants, with no difference found among females. Further analysis suggests that there may be differences between listeners on their direction of cardiac response to the same stimulus.

ADHERENCE TO A WORK-SITE RELAXATION PROGRAM: EFFECTS OF SETTING AND CONVENIENCE. D.E. Schotte*, F. Chan*,L.W. Frederiksen*. Dept. of Psychology, Va. Polytechnic Inst., Blacksburg, Va. 24061.

An on-site, off-site response cost manipulation was conducted in the context of a relaxation training program for University faculty and staff. Thirty-two faculty and staff members volunteered and were randomly assigned to one of four groups. Half of the groups were held at the work-site and half of the groups were held at a short distance from the work-site. Subjects were informed that the first two sessions were mandatory, but that attendance at the following four practice sessions was optional. The primary dependent measures were attendance, compliance with take-home relaxation practice monitoring forms and a final evaluative interview. Initially attendance and monitoring compliance were higher in the increased response cost group (off-site location). However, these differences washed-out over time. This finding is related to a pattern observed in several similiar compliance studies conducted by the third author. An attempt is made to predict these results on the basis of pretest measures administered.

ROLE OF MIDBRAIN OF ASCENDING NORADRENERGIC FIBERS ON EATING, DRINKING, AND ACTIVITY LEVELS IN RATS. Robert D. Shaver.* Dept. of Psychology, Washington and Lee University, Lexington, VA 24450 (Sponsor: D. G. Elmes)

Eighteen Sprague-Dawley rats were used to investigate the effects of dopamine and the lateral hypothalamus on eating, drinking, and activity over 24-hour time periods. Dopamine to the lateral hypothalamus was depleted either by radio frequency lesions to the substantia nigra, which are the cells of origin for dopamine feeding the hypothalamus, or by injecting 6-hydroxydopamine. Eating, drinking, and activity were monitored electronically and analyzed to show totals and circadian rhythm differences. Six radio frequency lesioned, six 6-hydroxydopamine lesioned and six unoperated control animals were used. Preliminary results indicated that there were selective differences between the two experimental groups and adipsia and aphagia were observed. Final results as they relate to the lateral hypothalamic syndrome and total day-night cycles will be discussed.

ADHERENCE TO A WORK-SITE RELAXATION PROGRAM: EFFECTS OF PERCEIVED CONTROL. A.W. Riley*. Dept of Psychology, Va. Polytechnic Inst., Blacksburg, Va. 24061

The reported study investigated issues of program attendence and practice from the theoretical framework of perceived control. University staff and faculty were offered a worksite health promotion program in relaxation techniques. As with many positive health behaviors, inadequate and irregular practice of relaxation impairs its efficacy. This study compared the effect of two practical program delivery strategies on attendence at program sessions and home relaxation exercise practice. A traditional didactic presentation was compared with a participative format in which subjects were allowed to make procedural choices and were encouraged to view the relaxation strategy as a means of increasing control over their health. Subjects were randomly assigned to conditions on the basis of their score on a measure of desire for control. An interaction was hypothesized between program strategy and subjects' need for control. While support was not provided for the interaction hypothesis, there was a main effect of program delivery style on attendence at training sessions, $p < .0045$. This effect is primarily due to the significantly greater number of drop-outs in the standard program. These results suggest that health promotion programs focused on the increased control attained by participants may significantly improve program attendence at work-site health promotion programs.

PERCEIVED CONTROL, INTERPERSONAL IMPACT AND ADJUSTMENT TO A HEALTH CARE PROCEDURE. Ann R. Penberthy, Stephen M. Auerbach*, Virginia Commonwealth Univ., and John P. McCasland*, MCV School of Dentistry, Richmond, VA.

Adjustment, satisfaction and interpersonal impacts were evaluated as a function of conditions designed to enhance perceived control for 102 patients being fitted for dentures over a 3-6 month period. Control was manipulated through a series of audio tapes which provided preparatory information and expectancy sets. Opportunities for actual behavioral involvement in decisions pertaining to treatment were also provided. Patients were seen for multiple contacts over the regular course of treatment in the dental school clinic, and a 6-9 month follow up was obtained. No main effects for treatment conditions were found, but interactions between treatment conditions and specific individual differences accounted for a significant proportion of variance in adjustment and satisfaction. A reversal of the predicted finding was obtained suggesting Externals (locus of control) did better in conditions providing increasing levels of control and Internals did progressively better in conditions providing decreasing degrees of control.

APPLICATIONS OF BEHAVIOR ANALYSIS FOR THE REFINEMENT OF STRATEGIES TO INCREASE SEAT-BELT WEARING. Wade Thompson*, and E. Scott Geller, Sponsor, Dept. of Psychology, VPI & SU, Blacksburg, VA 24060.

This presentation reported sequential analyses of individual seat belt usage at a large industrial complex (via categorizations of vehicles according to driver sex and license plate number), in order to study the impact of an incentive program as described in the prior paper by L. Paterson, L. Davis, and L. Keeton. A special "traceback analysis" was introduced to follow the belt wearing practices of individuals over sequential exposures to the same experimental condition. General findings were: 1) Belt wearing was only influenced slightly by repeated exposures to Baseline observations; 2) Belt wearing increased significantly with each consecutive distribution of an incentive flyer (up to four exposures); 3) During the Treatment phase, belt usage increased substantially in the A.M. (when flyers were not distributed) as a function of number of incentive flyers received in the P.M. (up to four exposures); 4) For drivers who had received three or more incentive flyers, repeated exposures to Follow-Up observations resulted in some decreases in belt wearing, but usage never reached the low pre-treatment levels (with as many as 11 consecutive exposures to Follow Up); and 5) For initial Follow-Up observations, drivers who had received only one or two incentive flyers showed higher belt usage than did drivers who had received no treatment experience; however, with repeated exposures to Follow Up, these drivers eventually showed reversals to pre-treatment baseline levels of belt usage.

Statistics Section

TREATMENT OF MULTICOLLINEARITY IN SIMULTANEOUS SYSTEMS OF LINEAR EQUATIONS. Oral Capps, Jr.* Dept. of Agricultural Economics, Va. Polytechnic Inst. and State University, Blacksburg, VA 24061

Multicollinearity in simultaneous systems of linear equations may result in statistically insignificant, theoretically inconsistent, imprecise, and unstable structural parameter estimates. Consequently, threats to both the proper specification and the effective estimation of structural relationships are likely to arise in practice. Multicollinearity problems have motivated the development of a number of operational variants of the ridge regression estimator in the context of the classical multiple regression model. This paper extends this development by integrating the ridge regression technique with the popular two-stage least squares (2SLS) technique to treat multicollinearity in simultaneous systems of linear equations. The derived estimator is consistent and possesses the same asymptotic distribution as the 2SLS estimator.

ACTIVITY AND THERAPEUTIC SYNERGISM IN CANCER TREATMENT. W.H. Carter, Jr., G.L. Wampler, D.M. Stablein, E.D. Campbell, Dept. of Biostatistics, Med. Col. of Va. Richmond, Va. 23298 (†The Emmes Corp., Potomac, Md.)

In work involving modelling of response surfaces to describe the effects of cancer chemotherapy treatments, it is important to define activity and therapeutic synergism in a statistically defensible manner. This requires the construction of confidence intervals around the estimated optimum treatment which has been achieved by use of an indirect method first proposed by Box and Hunter. Activity for a drug or a combination can be claimed at $100(1-\alpha)\%$ level of confidence when the $100(1-\alpha)\%$ confidence interval about the optimum treatment excludes a zero dose. Results of treatment of B16 melanoma and Lewis Lung Carcinoma with 3, 4 dihydroxybenzohydroxamic acid are used to demonstrate this definition. Extensions of this concept lead to a statistically valid definition of therapeutic synergism. If the confidence region about the optimum combination of k drugs does not contact any of the k-1 diminsional subspaces, then a k drug therapeutic synergism can be claimed. In the event that a k drug therapeutic synergism can not be claimed, there may be subsets of the drugs which do combine with therapeutic synergy. These concepts are demonstrated by two and three drug combination experiments in L1210 bearing $B6D2F_1$ mice.

A NEW METHOD OF CONSTRUCTING EGD-PBIB DESIGNS. Cheng-Tao Chang*. Dept. of Statistics, Virginia Polytechnic Inst. and State Univ., Blacksburg, Va. 24061.

Let $A_1, A_2, \ldots, A_n$ be n factors in a factorial experiment, with A_i having t_i levels $(i=1,2,\ldots,n)$. It is shown that an EGD-PBIB design with blocks of size t_i can be constructed, provided that $t_i \neq \max(t_1,t_2, \ldots, t_n)$. This procedure is based upon the notions of the $(1, 1, \ldots, 1)$th associate matrix, and generalized inner product and multiplication. This method is more general and more flexible than the method of Aggarwal (1973) in that any two treatment combinations can be γ-th associates where γ has at least two unity components, and it can be shown the number of possible candidates for such γ is $2^{n-i}-1$ for blocks of size t_i $(i=1,2,\ldots,n)$, where $t_1 \leq t_2 \leq \ldots \leq t_n$. This method is also more general than the Kronecker product method due to Vartak (1955).

A TEST FOR NORMALITY BASED ON THE EMPIRICAL CHARACTERISTIC FUNCTION. T.W. Epps, L.B. Pulley*, Depts. of Economics, U. of Va., Charlottesville, 22901, and Brandeis U., Waltham, Mass., 02154

If $X_1, X_2, \ldots, X_n$ is a random sample from a distribution $F(x)$, the empirical characteristic function (CF) is $\phi_n(t)=n^{-1}\sum_j \exp(itX_j)$, $-\infty<t<\infty$. The almost-sure convergence of $\phi_n(t)$ to $\phi(t)$, the CF of the population, together with one-to-one correspondence between $\phi(t)$ and $F(X)$, suggest the possibility of utilizing $\phi_n(t)$ in statistical inference. Here we apply this statistic to the problem of testing the composite hypothesis that $F(x)$ is normal, with μ and σ^2 unspecified. Let $\phi_0(t) = \exp(it\mu - t^2\sigma^2/2)$ be the CF under H_0. The test introduced in the paper is based on a weighted integral over t of the squared modulus of $\phi_n(t)-\phi_0(t)$. We compare its power with powers of prominent tests based on order statistics and on third and fourth sample moments. Although intended as an "omibus" test, it may be modified to enhance power against specific classes of alternatives.

THE ECCENTRICITIES OF MATHEMATICIANS. I. J. Good, Dept. of Statistics, Va. Polytechnic Inst. and State Univ., Blacksburg, Va. 24061

A discussion of some of the unusual actions of mathematicians and statisticians with special emphasis on those that the speaker had known personally.

COMBINING AITKEN ESTIMATORS ADDITIVELY, WITH APPLICATIONS TO FACTORIAL EXPERIMENTS. K. Hinkelmann, Virginia Polytechnic Inst. and State Univ., Blacksburg, Va. 24061, and O. Kempthorne*, Iowa State Univ., Ames, Iowa 50011.

We prove the following *Theorem:* Let $\underline{y}_j = X_j\underline{\tau} + \underline{\varepsilon}_j$ with $E(\underline{\varepsilon}_j) = \underline{0}$, $E(\underline{\varepsilon}_j\underline{\varepsilon}_j') = V_j\sigma^2$, where $\underline{y}_j$ is $n \times 1$, X_j is $n \times t$, $\underline{\tau}$ is $t \times 1$, $\underline{\varepsilon}_j$ is $n \times 1$ $(j=1,2,\ldots,r)$. Let $\underline{\xi}'\underline{\tau}$ be an estimable function. Then

$$\underline{\xi}'(\Sigma V_j^{-1})^{-1}\Sigma V_j^{-1}\underline{y}_j = \Sigma \frac{1}{\underline{\xi}'V_j\underline{\xi}}(\underline{\xi}'\hat{\underline{\tau}})_j / \Sigma \frac{1}{\underline{\xi}'V_j\underline{\xi}}$$

if and only if $\underline{\xi}$ is an eigenvector of V_j $(j=1,2,\ldots,r)$.

We show how this theorem can be applied to the problem of intra- and inter-block information from confounded factorial experiments.

DISTRIBUTIONAL APPROXIMATION FOR THE SUM OF LOGNORMAL RANDOM VARIABLES. Richard M. Kotz. Environmental Protection Agency and Va. Poly. Inst. and State Univ., Blacksburg, VA 24061.

It has been found that levels of industrial pollutants discharged from wastewater treatment systems generally follow a lognormal distribution. This distributional property and the assumption of independence of daily pollutant observations has provided a convenient method for setting daily industrial wastewater effluent limitations. These limits are generally set at the 95 or 99 percentile of the distribution of the pollutant concentration. Similarly, monthly or 30 day average limitations have been derived using the central limit theorem. In some industries, however, the industrial effluent is monitored only a few days per month, and thus the central limit theorem does not yield satisfactory results. Since the general distribution of the sum of a lognormal variates has not been derived, we present an approximation. Following an approach to approximating the distribution of quadratic forms, we use the lognormal distribution with adjusted parameters to present the distribution of a sum of lognormals. This approximation was shown to be more than adequate in a specific application. We conducted a simulation experiments to test this approximation for ranges of parameters and sample sizes encountered, including N = 2. All test showed a nonsignificiant difference between the approximated and simulated 99 percentile. Other experiments showed similar results at the 80, 90 and 95 percentiles.

A STOCHASTIC ORDERING FOR A NONCENTRAL MULTIVARIATE CHI-SQUARED DISTRIBUTION. Mark Marcucci and D. R. Jensen. Dept. of Statistics, VPI&SU, Blacksburg, VA 24061

The fact that the univariate noncentral chi-squared distribution is stochastically increasing in its noncentrality parameter plays an important role in the construction and analysis of hypothesis tests based on a χ^2 statistic. For the noncentral multivariate χ^2 distribution defined as the joint distribution of the diagonal elements of a noncentral Wishart random matrix, a weaker result is found to hold. Namely, if $\underset{\sim}{X}$ is distributed as $\chi^2_k(n,\underset{\sim}{\Sigma},M)$ and $\underset{\sim}{Y}$ is distributed as $\chi^2_k(n,\underset{\sim}{\Sigma},\lambda M)$, where $0 \leq \lambda \leq 1$, then $\underset{\sim}{X}$ is stochastically larger than $\underset{\sim}{Y}$. Applications of this result are discussed for some multiple testing problems and for some problems in statistical quality control.

THE DEPARTURE FROM NORMALITY OF SAMIUDDIN'S AND NAIR'S TRANSFORMATIONS OF THE SAMPLE CORRELATION COEFFICIENT. N. N. Mikhail, and P. L. Gatz, Jr.*. Liberty Baptist College, Lynchburg, VA 24506

In previous articles (Mikhail and others, 1981,1982) the first twenty moments of the sample correlation coefficient are derived and used to examine more thoroughly the behavior of the distributions of Samiuddin's and Nair's transformations under normal assumptions. The study of these two transformations using the first twenty moments up to $O(n^{-2})$ shows that the asymptotic formulae for these transformations converge to the normal distribution when $\rho = 0$, for any sample size $n \geq 20$. The first four moments derived by Hotelling (1953) are found to be sufficient to show this feature. For values of $\rho \geq 0$, the results show that the distributions of Samiuddin's and Nair's transformations depart very significantly from being normally distributed.

We advise all research workers who are seeking higher accuracy in their statistical tests concerning sampling correlation r not to fall into error of considering Samiuddin's and Nair's transformations of r to be normally distributed without reservation.

TEACHING STATISTICS TO GRADUATE STUDENTS IN THE HEALTH PROFESSION, Marianne Murdock*, Ph.D., Univ. of Va. Sch. of Nursing, Charlottesville, Va. 22903

Three years of teaching statistics to approximately 300 graduate students in nursing and public health have provided some insights into students' fears of statistics courses. A survey of these students indicates that 75% have avoided taking courses involving statistics. A large majority, 82%, feel statistics courses are an essential part of their graduate education. Of these students 56% believe some people can "do" statistics and some cannot. With these data in hand a series of courses were designed to meet the needs of graduate students who had little background in mathematics and much fear of statistics. The courses, which were replete with examples of health research, ranged from inferential and descriptive to multivariate statistics. The emphasis was on the application and understanding of the statistical tests rather than on their derivation. Students were also introduced to the use of computer software for problem solving. Location of textbooks suitable to the needs of the students proved difficult. At the conclusion of the courses students reported them as profitable.

ALLOCATION OF SAMPLE SIZE TO STRATA AND RELATED PROBLEMS. T.J. Rao*, Dept. of Stat., Va. Polytechnic Inst. and State Univ., Blacksburg, VA 24061

In this paper, we discuss Neyman's optimum allocation of sample size to strata when simple random sampling strategy is used in each stratum and consider the effects of deviations from this optimum allocation. Further, we shall examine the role of auxiliary information in obtaining Neyman's optimum allocation.

ROBUST ESTIMATION IN A FAMILY OF NEAR NORMAL DISTRIBUTIONS. Gary Ulrich. Dept. of Statistics, Va. Polytechnic Inst., Blacksburg, VA 24061

Robust estimation of the correlation coefficient has recently received much attention in the literature. The methods so far presented are difficult to apply in practice since their computational forms are sometimes very complex and their severe bias makes it difficult to know exactly what is being estimated. An adaptive estimation procedure is proposed and shown to be robust even in heavy tailed populations. The procedure is easy to use and is asymptotically unbiased when sampling from symmetrical bivariate populations. A bivariate family of heavy tailed distributions is introduced for use in the study of this estimator. Large sample properties of the procedure are explored and Monte Carlo methods are applied to investigate the small sample behavior.

DATA FUSION. E. J. Wegman Office of Naval Research, Arlington, VA 22217

In this paper, C^3I concepts are discussed. An axiomatic framework is laid down for fusion spaces based on C^3I concepts. Several structure theorems are proven for fusion spaces and a number of examples are constructed. Finally, a partial order is induced on equivalence classes in the fusion space and results on minimality are given.

NOTES

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Sampling Distribution of Proportions and Percentages with Applications for Finite and Infinite Populations

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ABSTRACT

In this article, moments of sample proportions and unbiased estimates of population proportions are derived using the application of symmetric functions and partitions for sampling without replacement from finite and infinite populations.

Gladen (1979, p. 278) suggested many distributional models for the sample proportion p, most of which utilized a two-moment graduation. Several of the models proposed by Gladen are included in our study.

A comparison of results with Scheaffer (1974) and Chakrabarty and Tsai (1976) is included.

1. INTRODUCTION

If we consider the situation in which sampling units in the population are divided into two mutually exclusive classes, Class 1 consisting of units possessing the attribute under consideration; and Class 2, consisting of those not possessing it.

For Population

Let
$$Z_i = \begin{cases} 1 & \text{if } Z_i \in \text{to class 1} \\ 0 & \text{if } Z_i \in \text{to class 2.} \end{cases} \tag{1.1}$$

Then
$$X = \sum_{i=1}^{N} Z_i = NP \tag{1.2}$$

where X is the population total, N is the population size, and P is the proportion of the sample units in the population.

For Sample

If we draw samples of size n from the population without replacements, we have:
$$z_i = \begin{cases} 1 & \text{if } z_i \in \text{to class 1} \\ 0 & \text{if } z_i \in \text{to class 2.} \end{cases} \tag{1.3}$$

Then:
$$x = \sum_{i=1}^{n} z_i = np \tag{1.4}$$

where x is the sample total, n the sample size, and p is the sample proportion.

Here in this paper, we use the application of symmetric functions and par-

titions to simplify the derivation of moments and unbiased estimates of proportions and percentages.

From the definition of symmetric functions, we denote the power sum and power product for samples by ( ) and [ ], respectively, and for the population by $(\ )_N$ and $[\ ]_N$, respectively.

Then (1.2) and (1.4) can be written in the form

$$X = (1)_N = NP. \tag{1.5}$$

$$x = (1) = np. \tag{1.6}$$

The combinatorial coefficient (Dwyer and Tracy, 1964, p. 1174) associated with a partition $R = r_1^{\pi_1} \ldots r_s^{\pi_s}$, ($r_i$ distinct), of unipartite number $r = \Sigma r_i \pi_i$ is

$$\phi(R) = \frac{r!}{(r_1!)^{\Pi_1}(r_2!)^{\Pi_2} \ldots (r_s!)^{\Pi_s}\, \Pi_1! \ldots \Pi_s!}. \tag{1.7}$$

2. MOMENTS OF SAMPLE PROPORTION p FOR FINITE POPULATIONS

We are interested in deriving the expected value E_N of the sample proportion p from finite population of size N using Carver functions C_r given by Carver (1930, p. 106),

$$C_r = \sum_R (-1)^{\lambda-1} (\lambda - 1)!\, \phi(R) e_\lambda. \tag{2.1}$$

where

$$e_\lambda = \frac{n^{(\lambda)}}{N^{(\lambda)}}, \quad n^{(\lambda)} = n(n-1) \ldots (n - \lambda + 1). \tag{2.2}$$

Definition 1

$$C_{r\,s} = C_{s\,r} = C_r \otimes C_s = C_s \otimes C_r \tag{2.3}$$

where $\otimes$ indicates symbolic multiplication involving appending of subscripts.

Before we proceed, we summarize some results given by Dwyer, Mikhail and Tracy (1978, p. 13), concerning the expected value of product of power sums.

Let (U_r) denote the product of (10 ... 0) (010 ...0) ... (0 ... 01), and let Q be a partition of 111 ... 1. Let [Q] be the corresponding power product. Then

$$(U_r) = \sum_Q [Q]. \tag{2.4}$$

Hence

$$E_N(U_r) = E_N \sum_Q [Q] = \sum_Q E_N[Q] = \sum_Q e_\lambda\, [Q]_N. \tag{2.5}$$

$$E_N(U_r) = \sum_R C_r(R)_N \tag{2.6}$$

Where R is the multipartite partition of coefficient unity and of r parts. Coalescing Columns, (2.6) becomes

$$E_N(1)^r = \sum_R \phi(R)\ C_r\ (R)_N \tag{2.7}$$

which represents the unipartite number Q = r and r in C_r is a column vector.

Theorem 1: The r^{th} moment of a sample proportion $p = x/n = \frac{1}{n}(1)$ for finite sampling is given by

$$E_N(p)^r = E_N\{\frac{(1)^r}{n^r}\} = \frac{1}{n^r} \sum_R \phi(R)\ C_r\ (NP)^{\lambda}. \tag{2.8}$$

Proof: Applying (2.7) and since the partition R has λ parts the result follows.

Example 1

$$E_N(p) = \frac{1}{n} \begin{matrix} C \\ 1 \end{matrix} (1)_N = P. \tag{2.9}$$

$$E_N(p^2) = \frac{\begin{matrix} C \\ 2 \end{matrix}}{n^2} (2)_N + \frac{1}{n^2} \begin{matrix} C \\ 1 \\ 1 \end{matrix} (1)_N^2. \tag{2.10}$$

$$= \frac{1}{n^2} \begin{matrix} C \\ 2 \end{matrix} (NP) + \frac{1}{n^2} \begin{matrix} C \\ 1 \\ 1 \end{matrix} (NP)^2.$$

$$E_N(p^3) = \frac{1}{n^3} \begin{matrix} C \\ 3 \end{matrix} (3)_N + \frac{3}{n^3} \begin{matrix} C \\ 2 \\ 1 \end{matrix} (2)_N(1)_N + \frac{1}{n^3} \begin{matrix} C \\ 1 \\ 1 \\ 1 \end{matrix} (1)_N^3 \tag{2.11}$$

$$= \frac{1}{n^3} \begin{matrix} C \\ 3 \end{matrix} (NP) + \frac{3}{n^3} \begin{matrix} C \\ 2 \\ 1 \end{matrix} (NP)^2 + \frac{1}{n^3} \begin{matrix} C \\ 1 \\ 1 \\ 1 \end{matrix} (NP)^3$$

etc.

3. UNBIASED ESTIMATES OF P FOR FINITE POPULATION

Here we derive the unbiased estimates E_N^* of the population proportion P, using a set of function C_r^* related to Carver functions given by

$$C_r^* = \sum_R (-1)^{\lambda-1} (\lambda-1)!\ \phi(R)\ e_\lambda^*. \tag{3.1}$$

where

$$e_\lambda^* = \frac{N^{(\lambda)}}{n^{(\lambda)}} \tag{3.2}$$

Theorem 2: The unbiased estimates of $P^r = \frac{1}{N^r}(1)_N^r$ for the population proportion P for finite sampling is:

$$E_N^*(P^r) = \frac{1}{N^r} \sum_R \phi(R)\ C_r^*\ (np)^{\lambda} \tag{3.3}$$

(Mikhail and Malik, 1978, 1979)

Proof: Applying (2.7) in a similar way to Theorem 1, we get the result.

Example:

$$E_N^*(P) = E_N^*\{\frac{1}{N}(1)_N\} = \frac{C_1^*}{N}(1) = \frac{C_1^*}{N}(np), \tag{3.4}$$

$$E_N^*(P^2) = E_N^*\{\frac{1}{N^2}(1)_N^2\} = \frac{C_2^*}{N^2}(2) + \frac{1}{N^2}C_{1\,1}^*(1)^2 \tag{3.5}$$

$$= \frac{1}{N^2}C_2^*(np) + \frac{1}{N^2}C_{1\,1}^*(np)^2.$$

$$E_N^*(P^3) = E_N^*\{\frac{1}{N^3}(1)_N^3\} = \frac{1}{N^3}C_3^*(3) + \frac{3}{N^3}C_{2\,1}(2)(1) + \frac{1}{N^3}C_{1\,1\,1}(1)^3 \tag{3.6}$$

$$= \frac{1}{N^3}C_3^*(np) + \frac{3}{N^3}C_{2\,1}(np)^2 + \frac{1}{N^3}C_{1\,1\,1}(np)^3,$$

etc.

4. MOMENTS OF SAMPLE PROPORTION p FOR INFINITE POPULATION

When the population size $N \to \infty$ Theorem 1, becomes,

Theorem 3: The r^{th} moment of the sample proportion p for infinite population

$$E(p^r) = \frac{1}{n^r}\sum_R \phi(R)\, n^{(\lambda)} P^\lambda . \tag{4.1}$$

Proof: From (2.8), and (2.1), since

$$\lim_{N\to\infty} N^\lambda C_r \to n^{(\lambda)}, \tag{4.2}$$

where λ is the number of parts in r.

The result follows immediately.

Example

$$E_N(p) = P. \tag{4.3}$$

$$E_N(p^2) = \frac{n}{n^2}P + \frac{n^{(2)}}{n^2}P^2. \tag{4.4}$$

$$E_N(p^3) = \frac{n}{n^3}P + 3\frac{n^{(2)}}{n^3}P^2 + \frac{n^{(3)}}{n^3}P^3 \tag{4.5}$$

etc.

5. UNBIASED ESTIMATES OF P^r FOR POPULATION PROPORTION P FOR INFINITE POPULATIONS

When the population size $N \to \infty$ Theorem 2, becomes,

$$E_N^*(P)^r = \sum_R \phi(R)(-1)^{r-\lambda}(r-\lambda)! \frac{n^\lambda}{n^{(r)}} P^\lambda \tag{5.1}$$

Proof: From (3.3) and (3.1), since

$$\frac{1}{N^r} C_r^* \to (-1)^{r-\lambda}(r-\lambda)! \frac{1}{n^{(r)}} . \tag{5.2}$$

The result follows immediately.

Example

$$E_N^*(P) = P .$$

$$E_N^*(P^2) = -\frac{n}{n^{(2)}} P + \frac{n^2}{n^{(2)}} P^2 .$$

$$E_N^*(P^3) = 2\frac{n}{n^{(3)}} P - 3\frac{n^2}{n^{(3)}} P^2 + \frac{n^3}{n^{(3)}} P^3 .$$

6. APPLICATIONS OF THEORETICAL RESULTS

Theorem 6.1. The sample proportion $p = x/n$ is an unbiased estimate of the population proportion X/N.

Theorem 6.2. The variance of p is

$$V(p) = E_N(p - P)^2 = \frac{P(1 - P)}{n} \left(\frac{N - n}{N - 1}\right) . \tag{6.1}$$

Using (2.2) and (2.1)

Corollary 1: If p and P are the sample and population percentages respectively, falling into class 1 and 2, (6.1) continues to hold for variance of p.

Theorem 6.3. An unbiased estimate of the variance of p, derived from the sample is

$$\hat{V}(p) = \left(\frac{N - n}{N}\right) \frac{p(1 - p)}{n - 1} . \tag{6.2}$$

using (3.3) and (3.4), (6.2) follows.
Also (6.2) gives the unbiased estimate of the variance of p for $N \to \infty$

$$v^*(p) = \frac{p(1 - p)}{n - 1} . \tag{6.3}$$

(6.3) was derived by Cochran (1963, p. 51) and emphasized its importance.

Theorem 6.4. The variance of the estimated variance $v(p)$ for a finite population is

$$\hat{V}(\hat{V}(p)) = \{\frac{N - n}{N(n - 1)}\}^2 V(p(1-p)). \tag{6.4}$$

$$V(p(1-p)) = \left[\frac{C_2}{n^2} - 2\frac{C_3}{n^3} + \frac{C_4}{n^4}\right](NP) + \left\{\left[\frac{C_{11}}{n^2} - 6\frac{C_{21}}{n^3} + 4\frac{C_{31}}{n^4} + 3\frac{C_{22}}{n^4}\right] - \left[\frac{C_1}{n} - \frac{C_2}{n^2}\right]^2\right\}(NP)^2 + \left\{\left[\frac{C_{111}}{n^3} + 6\frac{C_{211}}{n^4}\right] - 2\frac{C_{11}}{n^2}\left[\frac{C_1}{n} - \frac{C_2}{n^2}\right]\right\}(NP)^3 + \left\{\frac{C_{1111}}{n^4} - \frac{C_{11}^2}{n^4}\right\}(NP)^4. \tag{6.5}$$

Proof: Using (2.8) for r = 1,2,3, and 4, and collect terms we get the result.

Theorem 6.5. The variance of the estimated variance $V^*(p)$ for infinite population is

$$V(V^*(p)) = \frac{1}{n^3(n-1)^2}[(n-1)^2 P - (5n^2 - 12n + 7) P^2 - (n-1)(n^2 - 6n + 12) P^3 - 2(n-1)(2n-3) P^4]. \tag{6.6}$$

Proof: From the definition of C_r in (1.6) and taking limit as $N \to \infty$ we get (6.6).

7. THE DISTRIBUTION OF p

Gladen (1979, p. 278) suggested many distributional models for the sample proportion p, most of which utilized a two-moment graduation. Several of the models proposed by Gladen are included in our study.

Using the first four exact moments of p in section 2 of this paper, the skewness (β_1) and kurtosis (β_2) are calculated. The values of β_1 and β_2 are listed in column I of tables I, II, III and IV. These values of β_1 and β_2 can be compared with their respective values in columns II, III, and IV for the two-moment graduation of Beta, a scalar multiple of chi-square, and a beta-binomial distribution, respectively. The columns are listed according to their rank of superiority of being the best, the second and third best fitted distribution of the sample proportion p for a sample of size $n \geq 5$, drawn without replacement from a finite population of size $N \geq 50$. In table IV, the values of β_1 and β_2 for all fitted distributions are given as a limiting case for a population of size N = 1,000,000.

7.1 The Beta Model

For a sample proportion p of a sample size n drawn without replacement from a finite population of size N, the beta distribution with parameters α and β is given by

$$p \quad B(\alpha, \beta) \tag{7.1.1}$$

with the probability density function (p.d.f.)

$$f(p) = \frac{\Gamma(\alpha+\beta)}{\Gamma(\alpha)\Gamma(\beta)} p^{\alpha-1} (1-p)^{\beta-1} \tag{7.1.2}$$

The first two moments of p are then

$$E(p) = \mu = \alpha/(\alpha+\beta)$$
$$\text{Var}(p) = \frac{\alpha\beta}{(\alpha+\beta)^2(\alpha+\beta+1)} = \mu(1-\mu)/(\alpha+\beta+1) \tag{7.1.3}$$

TABLE I: VALUES OF β_1 AND β_2 FOR DIFFERENT MODELS, N = 50*

S	P		I	II	III	IV
5	.1	B1 =	1.08E+00	3.73E+00	6.61E+00	7.11E+00
		B2 =	3.49E+00	7.04E+00	1.29E+01	8.14E+00
5	.3	B1 =	1.15E-01	4.00E-01	1.71E+00	7.54E-01
		B2 =	2.75E+00	2.71E+00	5.57E+00	1.60E+00
5	.5	B1 =	1.03E-22	0.00E+00	7.35E-01	1.49E-25
		B2 =	2.66E+00	2.19E+00	4.10E+00	7.06E-01
5	.7	B1 =	1.15E-01	4.00E-01	3.15E-01	6.32E-01
		B2 =	2.75E+00	2.71E+00	3.47E+00	1.07E+00
5	.9	B1 =	1.08E+00	3.73E+00	8.16E-02	4.15E+00
		B2 =	3.49E+00	7.04E+00	3.12E+00	3.70E+00
10	.1	B1 =	3.40E-01	1.98E+00	2.94E+00	7.11E+00
		B2 =	2.92E+00	5.35E+00	7.41E+00	8.03E+00
10	.3	B1 =	3.65E-02	2.13E-01	7.62E-01	7.47E-01
		B2 =	2.87E+00	2.88E+00	4.14E+00	1.54E+00
10	.5	B1 =	1.18E-21	1.18E-21	3.27E-01	1.78E-24
		B2 =	2.87E+00	2.58E+00	3.49E+00	6.54E-01
10	.7	B1 =	3.65E-02	2.13E-01	1.40E-01	5.91E-01
		B2 =	2.87E+00	2.88E+00	3.21E+00	9.66E-01
10	.9	B1 =	3.40E-01	1.98E+00	3.63E-02	3.35E+00
		B2 =	2.92E+00	5.35E+00	3.05E+00	2.91E+00
30	.1	B1 =	2.52E-02	3.77E-01	4.90E-01	7.10E+00
		B2 =	2.68E+00	3.48E+00	3.73E+00	7.96E+00
30	.3	B1 =	2.70E-03	4.04E-02	1.27E-01	7.42E-01
		B2 =	2.92E+00	2.98E+00	3.19E+00	1.50E+00
30	.5	B1 =	1.02E-18	2.54E-19	5.44E-02	9.20E-26
		B2 =	2.95E+00	2.92E+00	3.08E+00	6.23E-01
30	.7	B1 =	2.70E-03	4.04E-02	2.33E-02	5.63E-01
		B2 =	2.92E+00	2.98E+00	3.03E+00	8.99E-01
30	.9	B1 =	2.52E-02	3.77E-01	6.05E-03	2.79E+00
		B2 =	2.68E+00	3.48E+00	3.01E+00	2.39E+00

*s = sample size (n), and 1.29E+01 = 1.29 x 10^1.

TABLE II: VALUES OF β_1 AND β_2 FOR DIFFERENT MODELS, N = 100

S	P		I	II	III	IV
5	.1	B1 =	1.25E+00	3.84E+00	6.91E+00	7.11E+00
		B2 =	3.76E+00	7.13E+00	1.34E+01	8.14E+00
5	.3	B1 =	1.34E-01	4.12E-01	1.79E+00	7.54E-01
		B2 =	2.75E+00	2.70E+00	5.69E+00	1.60E+00
5	.5	B1 =	9.05E-23	9.05E-23	7.68E-01	5.90E-25
		B2 =	2.63E+00	2.17E+00	4.15E+00	7.04E-01
5	.7	B1 =	1.34E-01	4.12E-01	3.29E-01	6.31E-01
		B2 =	2.75E+00	2.70E+00	3.49E+00	1.07E+00
5	.9	B1 =	1.25E+00	3.84E+00	8.53E-02	4.12E+00
		B2 =	3.76E+00	7.13E+00	3.13E+00	3.68E+00
10	.1	B1 =	5.21E-01	2.17E+00	3.27E+00	7.11E+00
		B2 =	3.22E+00	5.55E+00	7.91E+00	8.02E+00
10	.3	B1 =	5.58E-02	2.33E-01	8.48E-01	7.47E-01
		B2 =	2.88E+00	2.86E+00	4.27E+00	1.54E+00
10	.5	B1 =	0.00E+00	0.00E+00	3.64E-01	1.09E-25
		B2 =	2.84E+00	2.54E+00	3.55E+00	6.52E-01
10	.7	B1 =	5.58E-02	2.33E-01	1.56E-01	5.89E-01
		B2 =	2.88E+00	2.86E+00	3.23E+00	9.61E-01
10	.9	B1 =	5.21E-01	2.17E+00	4.04E-02	3.30E+00
		B2 =	3.22E+00	5.55E+00	3.06E+00	2.87E+00
30	.1	B1 =	5.58E-02	6.40E-01	8.48E-01	7.10E+00
		B2 =	2.88E+00	3.80E+00	4.27E+00	7.95E+00
30	.3	B1 =	5.98E-03	6.86E-02	2.20E-01	7.42E-01
		B2 =	2.96E+00	2.97E+00	3.33E+00	1.50E+00
30	.5	B1 =	4.89E-20	1.96E-19	9.43E-02	8.99E-26
		B2 =	2.96E+00	2.86E+00	3.14E+00	6.19E-01
30	.7	B1 =	5.98E-03	6.86E-02	4.04E-02	5.60E-01
		B2 =	2.96E+00	2.97E+00	3.06E+00	8.91E-01
30	.9	B1 =	5.58E-02	6.40E-01	1.05E-02	2.72E+00
		B2 =	2.88E+00	3.80E+00	3.02E+00	2.32E+00
50	.1	B1 =	5.32E-21	2.82E-01	3.64E-01	7.10E+00
		B2 =	2.84E+00	3.36E+00	3.55E+00	7.93E+00
50	.3	B1 =	4.19E-20	3.02E-02	9.43E-02	7.41E-01
		B2 =	2.96E+00	2.99E+00	3.14E+00	1.49E+00
50	.5	B1 =	6.21E-19	6.21E-19	4.04E-02	8.66E-26
		B2 =	2.98E+00	2.94E+00	3.06E+00	6.13E-01
50	.7	B1 =	2.62E-17	3.02E-02	1.73E-02	5.54E-01
		B2 =	2.96E+00	2.99E+00	3.03E+00	8.78E-01
50	.9	B1 =	0.00E+00	2.82E-01	4.49E-03	2.60E+00
		B2 =	2.84E+00	3.36E+00	3.01E+00	2.22E+00

TABLE III: VALUES OF β_1 AND β_2 FOR DIFFERENT MODELS, N = 200

S	P		I	II	III	IV
5	.1	B1 =	1.34E+00	3.90E+00	7.06E+00	7.11E+00
		B2 =	3.89E+00	7.18E+00	1.36E+01	8.13E+00
5	.3	B1 =	1.43E-01	4.18E-01	1.83E+00	7.54E-01
		B2 =	2.75E+00	2.69E+00	5.74E+00	1.59E+00
5	.5	B1 =	0.00E+00	0.00E+00	7.84E-01	3.67E-24
		B2 =	2.62E+00	2.16E+00	4.18E+00	7.03E-01
5	.7	B1 =	1.43E-01	4.18E-01	3.36E-01	6.30E-01
		B2 =	2.75E+00	2.69E+00	3.50E+00	1.07E+00
5	.9	B1 =	1.34E+00	3.90E+00	8.71E-02	4.11E+00
		B2 =	3.89E+00	7.18E+00	3.13E+00	3.66E+00
10	.1	B1 =	6.16E-01	2.26E+00	3.44E+00	7.11E+00
		B2 =	3.37E+00	5.64E+00	8.16E+00	8.02E+00
10	.3	B1 =	6.59E-02	2.42E-01	8.91E-01	7.47E-01
		B2 =	2.88E+00	2.85E+00	4.34E+00	1.53E+00
10	.5	B1 =	0.00E+00	7.35E-22	3.82E-01	9.78E-25
		B2 =	2.82E+00	2.52E+00	3.57E+00	6.51E-01
10	.7	B1 =	6.59E-02	2.42E-01	1.64E-01	5.88E-01
		B2 =	2.88E+00	2.85E+00	3.25E+00	9.58E-01
10	.9	B1 =	6.16E-01	2.26E+00	4.24E-02	3.29E+00
		B2 =	3.37E+00	5.64E+00	3.06E+00	2.85E+00
30	.1	B1 =	1.39E-01	7.66E-01	1.03E+00	7.10E+00
		B2 =	3.02E+00	3.96E+00	4.54E+00	7.94E+00
30	.3	B1 =	1.49E-02	8.20E-02	2.66E-01	7.41E-01
		B2 =	2.96E+00	2.96E+00	3.40E+00	1.50E+00
30	.5	B1 =	2.77E-20	0.00E+00	1.14E-01	8.02E-25
		B2 =	2.95E+00	2.84E+00	3.17E+00	6.17E-01
30	.7	B1 =	1.49E-02	8.20E-02	4.88E-02	5.58E-01
		B2 =	2.96E+00	2.96E+00	3.07E+00	8.88E-01
30	.9	B1 =	1.39E-01	7.66E-01	1.27E-02	2.69E+00
		B2 =	3.02E+00	3.96E+00	3.02E+00	2.30E+00
50	.1	B1 =	4.81E-02	4.16E-01	5.43E-01	7.10E+00
		B2 =	2.95E+00	3.53E+00	3.81E+00	7.93E+00
50	.3	B1 =	5.16E-03	4.46E-02	1.41E-01	7.40E-01
		B2 =	2.97E+00	2.98E+00	3.21E+00	1.49E+00
50	.5	B1 =	1.87E-19	1.87E-19	6.03E-02	8.56E-26
		B2 =	2.98E+00	2.91E+00	3.09E+00	6.11E-01
50	.7	B1 =	5.16E-03	4.46E-02	2.58E-02	5.52E-01
		B2 =	2.97E+00	2.98E+00	3.04E+00	8.74E-01
50	.9	B1 =	4.81E-02	4.16E-01	6.70E-03	2.57E+00
		B2 =	2.95E+00	3.53E+00	3.01E+00	2.19E+00

TABLE IV: VALUES OF β_1 AND β_2 FOR DIFFERENT MODELS, N = 1,000,000

S	P		I	II	III	IV
5	.1	B1 =	1.42E+00	3.95E+00	7.20E+00	7.11E+00
		B2 =	4.02E+00	7.22E+00	1.38E+01	8.13E+00
5	.3	B1 =	1.52E-01	4.23E-01	1.87E+00	7.54E-01
		B2 =	2.75E+00	2.69E+00	5.80E+00	1.59E+00
5	.5	B1 =	8.00E-23	8.00E-23	8.00E-01	2.34E-24
		B2 =	2.60E+00	2.14E+00	4.20E+00	7.02E-01
5	.7	B1 =	1.52E-01	4.23E-01	3.43E-01	6.29E-01
		B2 =	2.75E+00	2.69E+00	3.51E+00	1.06E+00
5	.9	B1 =	1.42E+00	3.95E+00	8.89E-02	4.09E+00
		B2 =	4.02E+00	7.22E+00	3.13E+00	3.65E+00
10	.1	B1 =	7.11E-01	2.35E+00	3.60E+00	7.11E+00
		B2 =	3.51E+00	5.73E+00	8.40E+00	8.02E+00
10	.3	B1 =	7.62E-02	2.52E-01	9.33E-01	7.47E-01
		B2 =	2.88E+00	2.85E+00	4.40E+00	1.53E+00
10	.5	B1 =	6.40E-22	6.40E-22	4.00E-01	2.70E-24
		B2 =	2.80E+00	2.50E+00	3.60E+00	6.49E-01
10	.7	B1 =	7.62E-02	2.52E-01	1.71E-01	5.87E-01
		B2 =	2.88E+00	2.85E+00	3.26E+00	9.56E-01
10	.9	B1 =	7.11E-01	2.35E+00	4.44E-02	3.27E+00
		B2 =	3.51E+00	5.73E+00	3.07E+00	2.84E+00
30	.1	B1 =	2.37E-01	8.88E-01	1.20E+00	7.10E+00
		B2 =	3.17E+00	4.10E+00	4.80E+00	7.94E+00
30	.3	B1 =	2.54E-02	9.51E-02	3.11E-01	7.41E-01
		B2 =	2.96E+00	2.95E+00	3.47E+00	1.49E+00
30	.5	B1 =	1.73E-20	0.00E+00	1.33E-01	2.21E-24
		B2 =	2.93E+00	2.81E+00	3.20E+00	6.16E-01
30	.7	B1 =	2.54E-02	9.51E-02	5.71E-02	5.57E-01
		B2 =	2.96E+00	2.95E+00	3.09E+00	8.85E-01
30	.9	B1 =	2.37E-01	8.88E-01	1.48E-02	2.67E+00
		B2 =	3.17E+00	4.10E+00	3.02E+00	2.28E+00
50	.1	B1 =	1.42E-01	5.47E-01	7.20E-01	7.10E+00
		B2 =	3.10E+00	3.69E+00	4.08E+00	7.92E+00
50	.3	B1 =	1.52E-02	5.86E-02	1.87E-01	7.40E-01
		B2 =	2.98E+00	2.97E+00	3.28E+00	1.49E+00
50	.5	B1 =	0.00E+00	8.00E-20	8.00E-02	0.00E+00
		B2 =	2.96E+00	2.88E+00	3.12E+00	6.10E-01
50	.7	B1 =	1.52E-02	5.86E-02	3.43E-02	5.51E-01
		B2 =	2.98E+00	2.97E+00	3.05E+00	8.71E-01
50	.9	B1 =	1.42E-01	5.47E-01	8.89E-03	2.54E+00
		B2 =	3.10E+00	3.69E+00	3.01E+00	2.16E+00

Using the first two moments of section 2, we have

$$\alpha = \frac{N(n-1)}{(N-n)} P$$
$$\beta = \frac{N(n-1)}{(N-n)} (1-P) \qquad (7.1.4)$$

For most of the values of N, n, and p, α and β are integers, a fact which makes the usage of the beta model very practical for sample sizes n as small as $n \geq 5$.

The values of β_1 and β_2 for the beta model are given in column II of Tables I-IV.

7.2 Chi-Square Model

Given the sample percentage p for a sample size n drawn without replacement from a finite population of size N, the scalar multiple of chi-square distribution with parameters λ and C, is given by

$$p \quad C\chi^2_\lambda \qquad (7.2.1)$$

or

$$p/C \sim \chi^2_\lambda$$

Where λ stands for the degrees of freedom (d.f.).

The p.d.f. for this model is

$$f(\chi^2) = \frac{1}{2^{\lambda/2}\,\Gamma(\frac{\lambda}{2})} \left(\chi^2\right)^{\frac{\lambda}{2}-1} e^{-\chi^2/2} \quad ; \; 0 \leq \chi^2 \leq \infty \,, \qquad (7.2.2)$$

with p/C as a chi-square variable. The first two moments of p are

$$E(p) = C\lambda$$
$$Var(p) = 2C^2\lambda \qquad (7.2.3)$$

Using the first two moments of section 2, we have

$$C = \left(\frac{1-P}{2n}\right)\left(\frac{N-n}{N-1}\right)$$
$$\lambda = \left(\frac{2nP}{1-P}\right)\left(\frac{N-1}{N-n}\right) \qquad (7.2.4)$$

The values of β_1 and β_2 for the chi-square model are given in column III of tables I-IV.

7.3 The Beta-Binomial Model

Gladen (1979, p. 278) proposed that the first two moments of the beta-binomial distribution are

$$E(p/n) = \mu = \overset{*}{\alpha}/(\overset{*}{\alpha}+\overset{*}{\beta})$$
$$Var(p/n) = \frac{\tau(n)}{n^2} = T = \frac{\mu(1-\mu)}{n} + \frac{n-1}{n}\sigma^2 \qquad (7.3.1)$$
$$= \overset{**}{\alpha}\overset{*}{\beta}/(\overset{*}{\alpha}+\overset{*}{\beta})^2(\overset{*}{\alpha}+\overset{*}{\beta}+1)$$

where μ and σ^2 are estimated first using the beta model of section 7.1, substituting for μ and σ^2 the parameters $\overset{*}{\alpha}$ and $\overset{*}{\beta}$ estimated as follows:

$$\overset{*}{\alpha} = \mu\left[\mu(1-\mu)-T\right]/T \qquad (7.3.2)$$
$$\overset{*}{\beta} = (1-\mu)\left[\mu(1-\mu)-T\right]/T$$

The values of β_1 and β_2 for the beta-binomial model are given in column IV of Tables I-IV.

7.4 Other Models

In addition to the distributional models discussed above, Gladen (1979, p. 281) also used $p^{\frac{1}{2}}$ and arsin ($p^{\frac{1}{2}}$), as follows:

$$p \sim p^{\frac{1}{2}} \qquad (7.4.1)$$
$$p \sim \sin^{-1}(p^{\frac{1}{2}}) \qquad (7.4.2)$$

These two models have also been examined, but were found to be inferior to the beta-binomial model and of no practical use with small sample sizes.

8. COMPARISON OF RESULTS

8.1 Concerning Sections 1 - 6

The sampling techniques used in sections 1,...,6 in deriving moments of p^r, of all values of r integers for sample percentages, and unbiased estimates of P^r, for all r of the population proportion P for finite and infinite sampling without replacement, are powerful as well as simple and concise. The mathematical expressions can be handled with ease compared with many techniques on sampling proportions and percentages. For example Scheaffer (1974, p. 188) considered infinite population, his unbiased estimate of P, and its variance are a special case of equation (6.3) in section 6 for $N = \infty$. Scheaffer gave an approximate expression for the variance of the variance of the estimator of P. This expression is in error and the correct result is given in equation (6.6) of section 6 which itself is a special case of equation 6.5.

Another example is the work of Chakrabarty and Tsai (1976) which is a special case of the techniques used in our study. For instance, their result in section 2.2 of their paper for $V(p_2) = \frac{P(1-P)}{n}\left(\frac{N-n}{N-1}\right)$ is identical to our result as shown in equation (6.1), section 6. Additionally, their unbiased estimate of the variance of p_2, $v(p_2) = \frac{P_2(1-P_2)}{n-1}\left(\frac{N-n}{N}\right)$ is identical to our result with (6.2) in section 6.

It is significant that Chakrabarty and Tsai (1976, p. 238) through their methods were unable to give an explicit expression for an unbiased estimator of the exact variance of P, they said ". . . An explicit expression for v(p) could not be obtained." This fact confirms that our sampling techniques which are presented in sections 1-6 are more powerful.

8.2 Concerning Section 7

The values of β_2 and β_2 in Tables I, II, III and IV show that the beta model is very good and adequate for practical purposes. The values listed in Column II compare relatively well with the exact values of β_1 and β_2 in Column I, even when the sample size is as small as 5. The chi-square model in Column III is also relatively good, especially with larger sample sizes. Examination of the values for the beta-binomial model reveals that it is considerably inferior to the beta model.

9. CONCLUSION

In this paper, the theoretical results in sections 1-6 are used to graduate a distributional model, of which the beta distribution is found to be the best two-moment graduation. The values of β_1 and β_2 in Tables I-IV show that the beta distribution is a good fit for small sample sizes, a fact which makes the beta model useful for any statistical test of sample proportion.

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A Rapid and Convenient Procedure for the Synthesis of Radiolabeled Di- and Tripeptides

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Abstract

This paper describes a procedure for the rapid synthesis of radiolabeled di-and tri-peptides. The technique makes use of a water soluble coupling reagent and catalytic dehydrogenation for deblocking the synthetic product. The radiolabeled peptide may be obtained in high yield and purity.

INTRODUCTION

The field of peptide synthesis has expanded to such an extent over the past decade that the novice who needs only to synthesize the occasional peptide quickly becomes lost in the deluge of possible methodologies to be followed. Fortunately, the availability of a wide assortment of small peptides from commercial sources such as Sigma Chemical Co. (St. Louis, Mo.) has made it possible to buy that occasional peptide unless the researcher needs it to be radiolabeled or modified in some way. Several years ago the authors found it necessary to use small radiolabeled peptides in a research project and were faced with the necessity to synthesize a small number of peptides on a limited budget. This paper is the result of several months of searching for a simple and reliable synthetic procedure for preparing radiolabeled peptides. Much of the individual methodologies have been published elsewhere by others and the value of the procedure presented here lies in the application of such methodologies in the combination described. The readers are referred to the book "Peptides: Structure and Biological Function" by E. Gross and J. Meinenhofer (Pierce Chemical Company, Rockford, Ill.) for an extensive review of peptide synthetic procedures.

The synthetic procedure described in this manuscript may be performed in less than one day and will give yields (up to 80%) of a product which may be used without further purification. The procedure utilizes a water soluble coupling reagent and protecting groups which may be simultaneously removed within 2 to 5 minutes.

Materials and Methods

For convenience we have chosen to use synthesis of glycl-L-leucine and L-leucyl-L-phenylalanine for description of the procedure. The use of amino acids with additional reactive groups would necessitate the use of alternate methodologies.

The carbobenzoxy (CBZ) protected amino acids (or peptides) and amino acid benzyl esters may be purchased from Sigma Chemical Company. Radiolabeled amino acids may be purchased from Amersham Radiochemicals (Arlington Heights, IL) or a similar radiochemical company. If you purchase a radiolabeled amino acid you may find it necessary to construct the benzyl ester derivative yourself (see later methods).

The coupling reagent EDC (1-ethyl-3-(3-dimethylaminopropyl carbodiimide) and deblocking reagent, palladium black, may be purchased from Sigma Chemical Company.

SYNTHESIS OF BENZYL ESTER DERIVATIVES:

The procedure used for the synthesis of the benzyl ester is essentially that of Zervas, Winitz and Greenstein (1957). The benzyl ester derivatives of selected amino acids are synthesized by mixing the ^{14}C labeled amino acid (50 μCi, 165mCi/mmole) with a known amount of non-radioactive amino acid (20 mmoles) and adding this mixture to an equal amount (20 mmoles) of p-toluensulfonic acid. Benzyl alcohol (80 mls) and benzene (40 mls) are added and the entire solution refluxed for 8 hours in a Dean & Stark distillation apparatus with the temperature of the reaction never exceeding 80°C. Upon completion of the reaction the light yellow solution is cooled to room temperature, 500 mls of diethylether added and the entire solution cooled to 0° - 2°C for 15 hours to precipitate the p-toluensulfonate amino acid benzyl ester. The melting point of the amino acid benzyl ester p-toluensulfonate is checked against the published value (158.5-160°C for leucine benzyl ester) (Zervas, Winitz, Greenstein, 1957). The solution is filtered and the precipitate added to chloroform (30 mls) at 0°C with constant stirring. Triethylamine is then added dropwise until a clear solution results. Ether (400 mls) is added to precipitate the triethyl ammonium p-toluensulfonate and the etheral solution supernatant concentrated in vacuo to approximately 2 mls and saturated with HCL gas to precipitate the amino acid benzyl ester salt.

The purity of the product is determined by melting point analysis, using a Hoover capillary point melting apparatus, and thin layer chromatography.

SYNTHESIS OF THE PEPTIDE:

The $[^{14}C]$ - amino acid benzyl ester was used without further purification by dissolving (10 mmoles) in methylene chloride or tetrahydrofuran (5 mls) containing freshly distilled triethylamine (20 μl) which is used to neutralized the associated HCl. The amount of triethylamine used in any synthesis is dependent upon the amount of benzyl ester used, such that equivalents of each are reacted. An equimolar amount of carbobenzoxy-amino acid (10 mmoles) and 1-ethyl-3-(3 dimethylamino propyl) carbodiimide (10 mmoles) are added and the reaction mixture stirred overnight at room temperature. The reaction mixture is then washed three times with 25 mls of water to remove the water soluble N-acyl urea which is a by-product of the reaction and unreacted CBZ amino acid, and three times with 0.1 N HCl (25 mls) to remove the unreacted benzyl ester. Evaporation of the mythylene chloride leaves the yellow oil residue of the carbobenzoxy and benzyl ester blocked peptide (CBZ-L-amino acid - L - $[^{14}C]$ amino acid benzyl ester.)

REMOVAL OF PROTECTING GROUPS:

The simultaneous removal of both the carbobenzoxyl and benzyl ester protecting groups is accomplished by dissolving the product in 3-5 mls methanol/formic acid (4.4%) and passing the solution over palladium black (50-100 mg) packed in a Pasteur pipette. ElAmin, et al., (1979) reported the rapid removal of such protecting groups by catalytic transfer hydrogenation. Formic acid was shown to be a very effective hydrogen donor for the rapid removal of these peptide protecting groups and a good solvent component, providing complete solubilization of most peptides and peptide derivatives.

THIN LAYER CHROMATOGRAPHY:

Purity of all benzyl esters and peptides synthesized was confirmed by thin layer chromatography. To test the identity of all synthetic products, cellulose thin layer chromatography sheets (Eastman) were spotted with 10 μl aliquots of the appropriate solutions as well as known peptides and amino acids, developed in an ethanol: acetic acid:

water (65:1:34; v/v/v) solvent, dried and sprayed with ninhydrin (0.4% solution in acetone).

In addition the peptides were hydrolyzed under vacuum in 6 N HCl at 100°C for 18 hours in sealed tubes. The hydrolysis products were dried under vacuum over KOH, 0.1 ml of water added, 10 µl spotted on the TLC sheet, and thin layer chromatography performed using the above procedure.

TNBS ASSAY OF FREE AMINO GROUPS:

Deblocking of CBZ-protected amino groups on peptides was followed by use of the trinitrobenzenesulfonic acid (TNBS) assay. Aliquots of formic acid/methanol solutions of CBZ - blocked peptides and amino acids prior to and following passage over the palladium black column were taken to dryness, redissolved in 1 ml of buffer (0.1 M 2-dimethylamino-ethanol, pH 9.0) and 1 ml of 0.1% TNBS (in water) added. The TNBS was permitted to react for 30 minutes at room temperature prior to addition of 1 ml of 10% sodium dodecyl sulphate (SDS) and 0.5 ml of 1 N HCl. Absorbance was measured at 340 nm using a known concentration of peptide for calculation of concentration of deblocked peptide.

RESULTS

Synthesis of benzyl ester:

Synthesis of the L-$[C^{14}]$ - leucine benzyl ester was essentially as described in the materials and methods. Purity of the product was determined using thin layer chromatography and figure 1 reveals that the benzylation reaction was essentially 100% complete with no radioactivity remaining at the position (R_f value of 0.84) of leucine. Catalytic deblocking of L $[^{14}C]$ leucine benzyl ester using palladium black and methanol/formic acid resulted in complete conversion to L-$[^{14}]$ - leucine. The extent of the reaction was determined by thin layer chromatography and scintillation counting and essentially 100% of the L-$[^{14}C]$ - leucine benzyl ester was converted to L-$[^{14}C]$ - leucine within 5 minutes (fig. 1).

Peptide synthesis:

Once purity of the L-$[^{14}C]$ - leucine benzyl ester had been established it could be used, without further purification. Synthesis of the peptide and deblocking as described in the materials and methods yields peptide in 70% to 85% yields as calculated from the recoverable radioactivity. Thin layer chromatographic analysis of an aliquot of the product revealed a single peak of radioactivity at an R_f corresponding to the peptide synthesized (figs. 2 and 3). Acid hydrolysis (overnight at 100°C in 6 N HCl in a vacuum sealed tube) of each product revealed a single spot of radioactivity on TLC plates which corresponded to free leucine (figs. 2 & 3). Spraying identical plates with ninhydrin revealed two ninhydrin positive spots corresponding to either leucine and phenylalanine or leucine and glycine depending on the peptide hydrolyzed (data not shown).

Time Course of Deblocking:

Although we routinely deblock the synthesized peptides by dissolving them in methanol/formic acid and passing them over a palladium black column we felt it might be informative to examine the rate at which deblocking occurs. To do this, we mixed 50 mg of palladium black in 5 mls of methanol/formic acid, added the blocked peptides (or blocked substrates, i.e. CBZ - glycine, etc) and removed aliquots with time. Each aliquot was taken to dryness and analyzed for free amino groups using the TNBS assay described in the materials and methods. Figure 4 shows the appearance of free amino groups (increased optical density at 340 nm) with time. The deblocking of CBZ-L-leucine was essentially 100% complete within 2 minutes (fig. 4).

DISCUSSION

The synthetic procedure described in this paper is not the only or even the best procedure for the synthesis of small radiolabeled peptides. However, the various techniques and reagents employed should facilitate the synthesis of such peptides by researchers who do not wish to become extensively involved in peptide synthesis. All reagents are commercially available and each step in the procedure may be undertaken using equipment available in most laboratories.

The reagent DCCD (dicyclohexylcarbodiimide) typically employed in this reaction yields a water insoluble dicyclohexylurea product which is difficult to remove from the reaction mixture. The EDC urea derivative is soluble in water and is easily removed along with unreacted substrates by the initial washings of the hydrophobic peptide product.

The use of carbobenzoxy and benzyl ester derivatives provides end group blocked peptide products which may be rapidly and completely deblocked by palladium black. ElAmin, et al. (1979) first reported the rapid removal of these protecting groups by catalytic transfer hydrogenation. The formic acid was shown to be a very effective transfer hydrodonor as well a good solvent for most peptides and peptide derivatives. The concentration of formic acid may be varied, but 4.4% proved to be most effective in deblocking a broad spectrum of protected substrates.

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Habitats and Distribution of the Pearl Dace, *Semotilus margarita* (Cope), in the Potomac River Drainage[1]

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ABSTRACT: The southern limit of the range of Semotilus margarita (Cope) in Atlantic slope drainages is in the Shenandoah River, Back Creek, Opequon Creek, Antietam Creek, Conococheague Creek, and Monocacy River, which are part of the Potomac River drainage located in the northern portion of the Blue Ridge of the Appalachian Mountains. In these tributaries, S. margarita inhabit small, clear, fertile streams whose headwaters are fed by underground springs that flow from limestone areas. Water in such streams is cool in summer and warm in winter, an important environmental factor that limits the distribution of S. margarita to such stream habitats.

INTRODUCTION

The pearl dace, Semotilus margarita (Cope) is widely distributed in most of Canada south of the Tundra, from the Maritime Provinces to the Peace River system of British Columbia (Hubbs and Lagler 1958; Scott and Crossman 1973). Its range extends southward through Montana and east of the northern portion of the Great Lakes region. From here it extends south along the Atlantic slope to Pennsylvania and Virginia (Lee et al. 1980). Despite its wide distribution S. margarita is rarely abundant, unlike its congeners Semotilus corporalis (Mitchill) and S. atromaculatus (Mitchill).

Fowler (1935, 1945) listed S. margarita as present in the Little Lynches River, Kershaw and Chesterfield counties, South Carolina, but on the basis of his description and illustration, the specimens were not S. margarita. Raney (1950) stated S. margarita occurred in the James River, Virginia, but his statement was based on Fowler (1945). Apparently the southern limit of the range of S. margarita in Atlantic slope drainages is that of the Shenandoah River (a tributary to the Potomac River), where it was taken from Back Creek in Augusta County, Virginia, by Ross (1959a). In Maryland, S. margarita was reported to occur rarely in the piedmont region (Mansueti 1950) and in mountain streams in the western counties (Schwartz 1963). It was listed as a rare and depleted species by Miller (1972).

(1) Contribution No. 1334, Center for Environmental and Estuarine Studies of the University of Maryland.

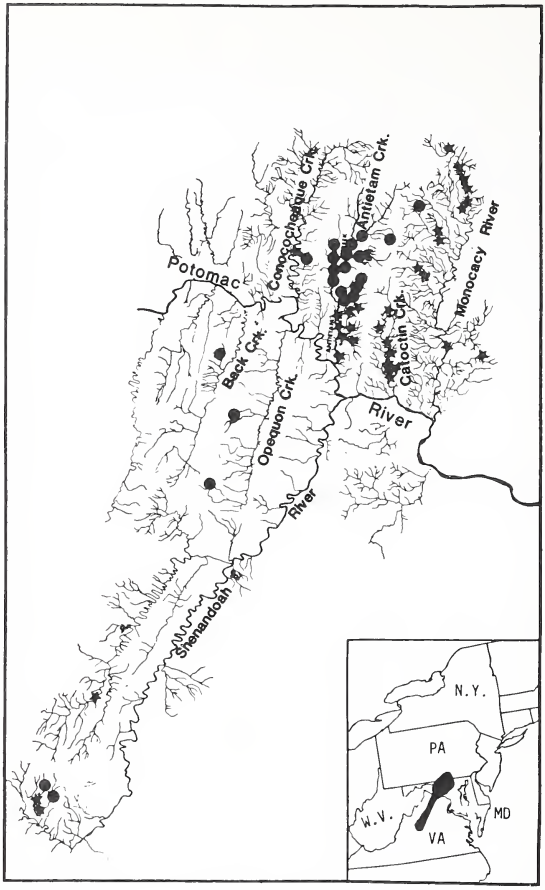

Fig. 1. Fish collection sites in the Potomac River drainage (solid circles, S. margarita present; solid stars, S. margarita absent).

There are different reports concerning the habitat of S. margarita. Eddy and Surber (1947) and Scott (1967) found it in lakes and bog streams, but rarely in small, clear, cool streams, while Greene (1935) and Hubbs and Lagler (1958) stated its habitat as cool, clear streams. In Canada, Scott and Crossman (1973) described the habitat of S. margarita to be cool, clear headwater streams in the south and bog drainage streams, ponds and small lakes in the north. Lalancette (1977) collected this species in Lake Gamelin, Quebec. Apparently, there are geographical differences in the habitat of S. margarita.

During the summers of 1968-1971, an extensive fish survey was conducted in Maryland and the adjacent portions of Virginia, West Virginia and Pennsylvania (Tsai 1973). Semotilus margarita was found in many tributaries of the Potomac River. Life history and tuberculation of S. margarita in Hamilton Run, a small tributary of Antietam Creek, were previously described (Fava and Tsai 1974, 1976). This paper reports the habitat and distribution of S. margarita in the Potomac River drainage.

MATERIALS AND METHODS

During the 1968-71 survey (Tsai 1973), a total of 61 sites were investigated in tributaries of the Potomac River. These tributaries are the Monocacy River, Catoctin Creek, Antietam Creek, Opequon Creek, Back Creek, Conococheaque Creek and Shenandoah River (Fig. 1). At each site fish were collected by a 220-volt AC electroshocker. Water quality, including water temperature, dissolved oxygen

content, pH, conductivity, hardness, turbidity, alkalinity, acidity, chloride, total phosphates and nitrite-nitrate nitrogen, were determined by standard methods (American Public Health Association, 1971). The stream width and depth were measured and bottom substrates and aquatic vegetation were described. Water quality and stream characteristics were compared by use of the t-test (Snedecor 1961) between the sites where S. margarita was present and those sites were it was absent to determine the habitat requirements.

RESULTS

Distribution

Semotilus margarita was found in 24 of the 61 sites (Fig. 1). In the Shenandoah River it was found at two localities, Blacks Run (Rockingham County) and a spring-fed creek near Mt. Zion (Augusta County) in Virginia.

S. margarita is one of the dominant species in Antietam Creek and was taken from tributaries, Hamilton Run, Little Antietam Creek, East Branch, West Branch and Falling Spring in Washington County, Maryland, and Franklin County, Pennsylvania. Of the 24 Antietam Creek sites investigated, 16 had S. margarita. It was rare in other tributaries of the Potomac River: Spring Run, a tributary of Monocacy River, Adams County, Pennsylvania; a small tributary of Conococheaque Creek, Washington County, Maryland; Back Creek, Berkeley County, West Virginia; and Adams Creek, Frederick County, Virginia; and a small tributary of Opequon Creek, Jefferson County, West Virginia.

HABITATS

Semotilus margarita was only found in small streams; their widths ranged between 0.61 m and 4.6 m, significantly smaller than those streams where S. margarita was absent (Table 1). Depths of the streams ranged between 0.15 m and 1.22 m, slightly deeper than the large streams where S. margarita was absent. It is evident that S. margarita was associated with small but relatively deep streams.

Table 1. A comparison of physical characteristics and water quality (mean ± standard deviations; number of sites in parentheses) between the sites where S. margarita was present and the sites where S. margarita was absent during the summers 1968-1971.

Stream characteristics	S. margarita present	S. margarita absent
Physical characteristics		
Stream width (m)	2.91±0.44(23)**	7.76±1.42(37)
Stream depth (m)	0.41±0.04(22)**	0.35±0.03(37)
Water Quality		
Air temperature (C)	23.88±0.56(24)	23.10±0.56(37)
Water temperature (C)	18.10±0.56(24)**	20.10±0.49(37)
Hardness (mg/ℓ as $CaCO_3$)	160.46±6.47(16)**	103.50±8.80(37)
Conductivity (μmhos)	351.50±24.02(24)**	260.30±18.21(37)
Alkalinity (mg/ℓ)	123.00±10.56(16)**	74.96±6.80(36)
Acidity (mg/ℓ)	13.20±2.36(15)**	3.7±1.07(29)
Total phosphates (mg/ℓ)	0.24±0.09(16)**	1.16±0.31(37)
Nitrite-nitrate Nitrogen (mg/ℓ)	3.38±0.66(16)**	0.29±0.05(9)
Dissolved oxygen (mg/ℓ)	9.67±0.24 (24)*	8.67±0.29(37)
Turbidity (mg/ℓ)	14.63±2.95(16)	13.10±1.08(37)
Dissolved solids (mg/ℓ)	196.90±13.96(15)	171.80±15.64(33)
Chloride (mg/ℓ)	14.77±2.27(16)	16.90±2.07(37)

* Significant difference at 1% level ($P<0.01$)
** Significant difference at 5% level ($P<0.05$)

On the basis of 14 water quality characteristics compared between the streams with S. margarita and those without (Table 1), S. margarita was associated with water which had lower summer temperature but higher values of hardness, conductivity, acidity, alkalinity, higher concentrations of dissolved oxygen and nitrite-nitrate nitrogen, but was lower in phosphates. These suggested that S. margarita inhabited cool, fertile streams.

The bottom substrates were combinations of gravel, sand, mud and occasionally rocks. There was no observable difference in substrate between the sites where S. margarita was present and the sites where it was absent. However, submerged or semisubmerged weeds were often more abundant at sites where S. margarita was present.

DISCUSSION AND CONCLUSION

The Shenandoah River, Back Creek, Opequon Creek, Antietam Creek, Conococheague Creek, and Monocacy River, which are tributaries of the Potomac River are located in the northern portion of the Blue Ridge of the Appalachian Mountains. This portion of the Blue Ridge is rich in limestone. Many of the streams in this region have headwaters which are fed by clean, cold underground springs. Comparatively deep water and cool summer temperatures in such small streams indicates relatively high flow rates of the spring water that feeds them. High nitrite-nitrate nitrogen and dissolved oxygen, but low phosphate concentrations suggest that these streams are enriched by inorganic nutrients from the springs and that there are high rates of photosynthetic activity by aquatic vegetation. Such small, cool, fertile streams are the habitat of S. margarita in the Potomac River drainage. These small streams are similar to those found in Wisconsin (Greene 1935) and the Great Lakes region (Hubbs and Lagler 1958), New York (Sheldon 1968) and some parts of Canada (Scott and Crossman 1973), but are different from the bog streams and lakes described by Eddy and Surber (1947), Scott (1967), and Lalancette (1977).

Because S. margarita occurs in small streams as well as in lakes, the size of water body and current velocity appear not to be the environmental factors that limit the distribution of this species. Water of the proper temperature appears to be its most important requirement. In Canada, S. margarita is distributed in relation to the 12.8-15.6C July isotherm (Scott and Crossman 1973). In the Potomac River this species occurred in waters where summer water temperatures were 18.1 $\pm$ 0.56C, several degrees lower than in streams which had no S. margarita. However, the 12-hr. median lethal temperature of S. margarita was 31.1C (McKee and Wolf 1963). In the laboratory, S. margarita lived well at 23-24C for more than three months (Tsai 1979). Unlike trout which need cold water during the summer, the low summer water temperature is apparently not an important factor for S. margarita.

In Hamilton Run of Antietam Creek, S. margarita was taken year-round (Fava and Tsai 1976). It is unlike other headwater inhabiting fish which migrate downstream in the winter when the streams were covered with ice or low flow during the dry summer season. Water temperature in the spring fed streams is more stable through the year than those fed with surface water. In Hamilton Run, the water temperature ranged from 8.9C in January to 18.9C in July (Fig. 2), differing greatly from the surface water fed streams which went from about zero degree(C) in winter to as high as 28C in summer in Maryland. The gonadal maturation process of S. margarita starts in midsummer and continues slowly to March, with reproduction in April (Fava and Tsai 1976). Most of fishes which live in the streams fed by surface water become inactive on the bottom in a state close to anabiosis (Macan 1963) and their gonadal maturation process nearly ceases during the winter period. Therefore, the warm water during the winter might be an important factor for survival and reproduction of S. margarita, and an important environmental factor that limits this species to such habitats.

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The Campanulaceae (including Lobelioideae) of Virginia

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ABSTRACT -- The Campanulaceae (including Lobelioideae) of Virginia is surveyed systematically. The genera treated are Campanula (4 species), Lobelia (8 species), and Triodanis (1 species, 2 varieties). A discussion of the taxa, keys to the genera and species, descriptions, flowering dates, and ecological data are included. Virginia distribution maps of the 14 included taxa are presented with a total of 45 new county records being reported.

The study presented here is a systematic treatment of the Campanulaceae (including Lobelioideae) of Virginia. The family is represented in the state by three genera, Campanula, Lobelia, and Triodanis, with a total of 14 taxa. This paper was prepared as a contribution to the proposed Flora of Viriginia. It is not a formal revision of the Campanulaceae, but treats only those taxa which range into Virginia.

Roughly 90 per cent of Virginia's counties and independent cities were visited during field work for this study, resulting in a total of forty-five county records. A complete set of voucher specimens for all new records has been deposited in the Herbarium of the College of William and Mary (WILLI). Duplicate specimens have been deposited in the Herbarium of the University of North Carolina (UNC). A total of approximately 1750 Virginia specimens were examined and annotated with additional study being made of many specimens from outside the state.

Species descriptions, ecological data, and flowering dates are from original observations and measurements of Virginia material.

Keys and ranges outside Virginia are based on Bradley (1975), Correll and Johnston (1970), Fernald (1950), Gleason and Cronquist (1936), McVaugh (1936), and Radford et al. (1968), as well as on original observations and data.

Nomenclature for the genus Campanula follows that used by Radford et al. (1968), as does that for Lobelia with the following exceptions: L. elongata follows McVaugh (1936); L. georgiana follows Bowden (1959); and L. spicata follows McVaugh (1936), but with varieties not being distinguished. Nomenclature for Triodanis follows Bradley (1975). Etymology follows Fernald (1950) and chromosome numbers were obtained from Fedorov (1969).

Distribution maps are included for all taxa occurring in Virginia (Figures 1-14). Solid dots represent specimens examined and annotated from a county, while open circles represent reports in the literature of a species' occurrence in the given county. Solid triangles represent specimens examined and annotated from independent cities, while open triangles represent literature reports from independent cities. Literature reports were taken primarily from Massey

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(1961) and McVaugh (1936). The distributional data presented here were made available to Dr. A. M. Harvill, Jr., of Longwood College, Farmville, Virginia, for inclusion in the Atlas of the Virginia Flora, Part II. Dicotyledons (Harvill et al. 1981).

The genus Campanula in Virginia is composed of four species, three of which are native. The native species include Campanula americana, C. aparinoides, and C. divaricata. The introduced species, Campanula rapunculoides, occasionally escapes cultivation and spreads into adjacent habitats. All of these taxa have ranges which are limited in Virginia mainly to the Blue Ridge and the Valley and Allegheny physiographic provinces.

Campanula americana, while in large part restricted to the western parts of the state, has an interesting range extension into the Costal Plain on the Peninsula of Virginia where it occurs on marl slopes near the James and York Rivers. The calcareous nature of the soil in these areas apparently fulfills an ecological requirement of this species and thus results in its disjunct distribution. Harvill (1965) has discussed this disjunction and it fits the classical pattern of Mountain-Coastal Plain disjuncts known to occur in Virginia (Braun 1937, Fernald 1937). A possible explanation here is that only in special edaphic or hydrologic situations (such as marl areas) did certain species persist during the xerothermic period of post-glacial times (Harvill 1972a, 1972b).

Campanula rapunculoides, a weedy introduction from Europe, escapes in the western part of the state. It was observed and collected there on four occasions by the author as a roadside and field weed. This species is easily distinguished from the native taxa by the much larger size (1.7-3.5 mm long) of its campanulate corollas.

Campanula aparinoides, known from only ten counties in Virginia, has but one Piedmont (Fluvanna Co., Diggs 584, WILLI) and one Coastal Plain (Sussex Co., Fernald & Long 12484, GH, NY) station, thus being rare and localized outside the western, mountainous area of the state. This sprawling, small flowered species is easily overlooked in the field and this coupled with the relative inaccessibility of its boggy habitat raises the question of whether the sketchy distribution pattern of the species is at least in part a collecting artifact. However, recent attempts to locate this species in apparently suitable habitats have usually proved unsuccessful, and Campanula aparinoides seems to be genuinely rare in Virginia except in a few localities in the mountains.

Campanula divaricata is also confined primarily to the mountainous areas of the state, typically on rocky banks or ledges. However, unlike Campanula aparinoides, C. divaricata probably occurs in every county in the western mountainous section and is usually abundant in suitable habitats.

The genus Triodanis, as treated in the present paper, is represented in Virginia by one native species, with two varieties: T. perfoliata var. perfoliata and var. biflora. Bradley (1975), in his study of hybridization between these two taxa concluded that vigorous hybrid offspring occurred and that a nearly continuous gradient existed between the two taxa in characters traditionally used to separate them at the species level; i.e. pore position and the shape of the floral bracts. Therefore recognition of these taxa at the level of species is not considered justified. There is only one character not showing a gradient between these two varieties: the absence of chasmogamous flowers in the lower inflorescences of var. biflora. According to Bradley, this reduction in the number of chasmogamous flowers acts as a partial isolating

mechanism and insures the production of selfed seeds which tends to propagate the syndrome of characters seen in var. biflora. This persistent character correlation therefore justifies distinction at the varietal level (Bradley 1975). Personal observations and measurements made during the course of the present study support the work of Bradley and thus lend support to the recognition of these taxa at the rank of variety.

Triodanis perfoliata var. perfoliata has been found in all of the physiographic provinces of Virginia, usually in disturbed sites and weedy areas and is relatively common. Mixed colonies of the two varieties have been observed with var. biflora usually being much less common. Triodanis perfoliata var. biflora is known from only twelve stations in Virginia, all of these being confined to the eastern Piedmont or Coastal Plain. This is probably partially a collecting artifact, but this considered, Triodanis perfoliata var. biflora is still rare in comparison with the typical variety.

The largest genus studied is Lobelia with a total of eight species occurring in the state, all native. The best known member of the genus is the Cardinal Flower, Lobelia cardinalis. This showy perennial is extremely widespread in Virginia, probably occurring in every county. In the more humid mountainous areas of the state, Lobelia cardinalis is often seen in large colonies in open marshy fields as well as in wooded habitats. In the less humid Piedmont region, the typical habitat is a shaded semi-swampy area or creekbank. Lobelia cardinalis is often seen growing in mixed colonies with another member of the genus, L. siphilitica, with which it is occassionally confused before anthesis. Despite the close sympatry and overlap in flowering period between these two species, no hybrid material from Virginia has been located and they seem to be well isolated reproductively. Several unusual color forms of Lobelia cardinalis have been examined. These include forma rosea (Fairfax Co., Bradley 4522, GMUF; Roanoke Co., Wood 6760, US), forma alba (Madison Co., Mazzeo 1706, NA), and an intermediate form having white corollas with pink veins (Roanoke Co., Wood 6761, US). These forms, however, are extremely rare with a total of only four individuals observed from the whole state.

Lobelia siphilitica is a large, showy member of the genus that as mentioned above is often found in mixed colonies with L. cardinalis. The range of Lobelia siphilitica is throughout the state except in the eastern Piedmont and parts of the Coastal Plain. An interesting aspect of its distribution is an extension onto the Coastal Plain in the central part of the state, particularly on the Peninsula of Virginia. This is possibly the result of the calcareous nature of the soil in this area which as mentioned above is also thought to be responsible for the disjunct occurrence of Campanula americana in this part of the state. Another possible explanation for this distribution pattern is dissemination by way of major rivers from the Piedmont onto the central Coastal Plain. Lobelia siphilitica was historically used in the treatment of veneral disease and like L. inflata exhibits poisonous properties (Muenscher 1961).

The distribution of Lobelia puberula in Virginia is rather unusual. This pubernulent perennial occurs commonly in most areas of the Coastal Plain and Piedmont, but has a very patchy distribution in the far western part of the state where only seven counties are known to have stations.

Lobelia georgiana is at the present time the most taxonomically interesting member of this family occurring in Virginia. There seems to be an unusually broad scope of

variation present in the Virginia material of this species with several characters including leaf texture, number of teeth per calyx lobe and degree of erectness of the stem varying widely. It became evident early in work with this species that a conclusive explanation for this variability was beyond the scope of this study. Some possible explanations include: 1) a great deal of phenotypic plasticity being expressed differently under varying environmental conditions; 2) hybridization with sympatric species; or 3) some past relationship with Lobelia amoena. The third possibility was added due to the fact that some characters occurring within one of the extremes of variation of Lobelia georgiana seem to closely resemble characters of L. amoena, a species occurring to the south of Virginia. Additionally, Lobelia georgiana has in the past been treated as a variety of L. amoena (L. amoena var. glandulifera Gray). The present paper however agrees with Bowden (1959) in keeping Lobelia georgiana as a separate species on the basis of cytology as well as on morphological grounds. A thorough study of this species over its entire range, possibly including biosystematic work, would be worthwhile.

Lobelia elongata, the type locality of which is Northwest, Norfolk Co. (City of Chesapeake) (Heller 1246, US), is very rare or possibly extinct in the Virginia portion of its range at present. The last reported collection was made by Fernald (Norfolk Co., 14028, US) in 1941. Attempts by the author to locate this or other colonies were unsuccessful.

Lobelia nuttallii, a small slender member of the genus, is confined primarily to the southeastern Piedmont and southern Coastal Plain in Virginia. It is easily distinguished from other members of the genus that occur in the state by the combination of its small flower size (10.5 mm long) and narrow leaves, as well as by its open, few flowered inflorescences.

Lobelia inflata is the most weedy member of the genus found in Virginia and is distributed throughout the state in a variety of habitats. It is able to grow in situations much drier than other Virginia members of the genus and is often locally common. Historically, the leaves were dried and smoked by the American Indians (Kingsbury 1964). Commercially, it is the source of the alkaloid, lobeline, which is used in anti-smoking preparations (Krochmal and Magee 1971). Medicinally, Lobelia inflata has been used in the treatment of respiratory conditions, but is poisonous when taken in larger doses (Muenscher 1964). Cases of animal poisoning have also been reported (Kingsbury 1964).

The final member of the genus to be discussed is Lobelia spicata. This species can often be found in rich wooded sites in the Piedmont and Mountains, but is much less common on the Coastal Plain of Virginia. This is a quite variable species and has often been separated into a number of varieties (McVaugh 1936). However, due to the continuous nature of this variation in the Virginia material, the present paper does not recognize the variability as warranting varietal status.

TAXONOMY

CAMPANULACEAE, the Bellflower or Harebell Family

Annual, biennial, or perennial herbs, often with milky sap; leaves alternate, simple, exstipulate; flowers perfect, actinomorphic to zygomorphic; calyx lobes usually 5; corolla typically 5-merous, sympetalous, campanulate to rotate to bilabiate; stamens usually 5, alternate with the corolla

lobes, separate or united; anthers separate or united into a tube; pistil 1; ovary inferior, 2-3 locular, with many ovules; placentation axile; capsule dehiscent by lateral or apical pores. A widely distributed mostly herbaceous family of 60-65 genera and between 1800 and 2000 species. Most species characterized by being strongly protandrous with the style and stigma involved in the presentation of pollen. While the Campanulaceae is often divided into 2 or even 3 separate families on the basis of a few prominent features of floral morphology, the presence of numerous shared characters as well as intermediate forms argues against such a treatment.

Key to Genera of Virginia Campanulaceae

1. Corolla actinomorphic; anthers distinct; capsule opening laterally (Subfamily Campanuloideae).....2

    2. Flowers only chasmogamous, pedicellate, terminal or in axils of petioled or basally tapering leaves: corolla campanulate or rotate; annuals or perennials..... Campanula

    2. Flowers chasmogamous and/or cleistogamous, sessile in axils of clasping leaves; corolla rotate; annuals..... Triodanis

1. Corolla zygomorphic; anthers connate; capsule opening apically (Subfamily Lobelioideae)..... Lobelia

1. Campanula L., Bellflower, Bluebell

Perennial, biennial, or annual, erect or sprawling herbs; leaves alternate, exstipulate, ovate to nearly linear, often greatly narrowed to a petiole, margins serrate to dentate to rarely entire, the teeth often callose-tipped; flowers perfect; calyx lobes 5; corolla actinomorphic, campanulate to rotate, 5-parted, joined below, white, purple, or blue; stamens 5, separate; filaments broadened basally; stigma 3-lobed; ovary inferior; capsule 3-locular, laterally poricidal; seeds many, usually lustrous. (A diminutive of Latin campana, a bell, from the shape of the corolla.) A large (approximately 300 species), diverse, and ornamentally important genus of wide distribution in the northern hemisphere, found primarily in temperate regions.

Key to Campanula L.

1. Corolla rotate; style downcurved; capsule with pores above middle ..... C. americana

1. Corolla campanulate; style essentially straight; capsule with pores below middle..... 2

    2. Corolla 1.7 cm or more long; capsule more than 5 mm long; introduced species..... C. rapunculoides

    2. Corolla 0.8 cm or less in length; capsule less than 5 mm long; native species.....3

        3. Style equal to or shorter than corolla; stems weak, reclining, with retrorse barbs; plant of marshes and bogs..... C. aparinoides

        3. Style exserted, longer than corolla; stems erect, ascending, without retrorse barbs; plant of rocky woods or banks..... C. divaricata

1. Campanula americana L. (American), Tall Bellflower. Annual (biennial) from a weak taproot; stems erect, angled, glabrous to slightly pubescent, 24-153 cm, usually branched above, occasionally reddish below; leaves ovate to lanceolate, 1.0-5.6 cm wide, 3.5-17.3 cm long, glabrous to pubescent, serrate to crenate, acute to acuminate, tapered to both ends, often greatly narrowed to a petiole, reduced and narrowed up the stem; inflorescence an elongate raceme or thyrse to 96 cm long; 1-3-(6) flowers per node; bracts leafy to linear above, glabrous to pubescent, glandular serrate to entire; calyx glabrous to slightly pubescent, lobes 0.5-0.8 mm long, entire to toothed; corolla rotate, 12-17 mm long, 18-28 mm wide, lobes broadly lanceolate to triangular, glabrous to pubescent along veins, ciliate at tips, blue to nearly violet; style downcurved, exserted; capsule 0.8-1.2 cm long, 0.3-0.65 cm wide, opening laterally by pores near top; seeds 1.2-1.5 mm long, 0.9-1.1 mm wide, light tan to brown. (N=29, 51) June to October; rich woods, limestone areas, slopes, riverbanks; common in Virginia primarily in the mountains with disjunct populations on the Coastal Plain; Ont. to Minn. and S.D., south to Fla., Miss., and Kan.

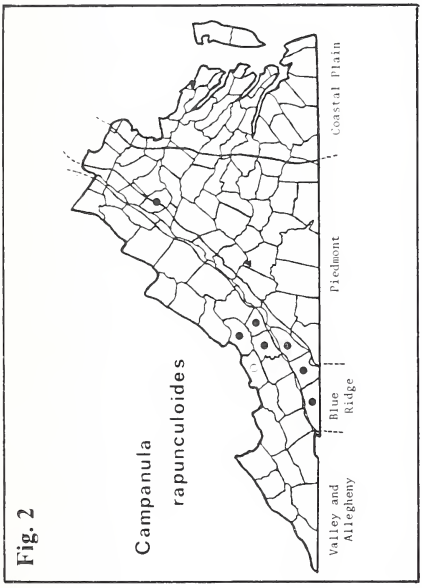
2. Campanula rapunculoides L. (like C. rapunculus, the Rampion), Rover Bellflower, False Rampion. Perennial from a creeping rhizome; stems erect, slightly pubescent to glabrous; 15-121.5 cm, often reddish below; leaves 0.9-5.9 cm wide, 1.4-17 cm long, serrulate to serrate, acute; stem leaves elliptic with long petioles; bracts leafy to distinct, glabrous to pubescent, acute; pedicels 5-7 mm long, hispidulous to nearly glabrous; flowers nodding; calyx hispidulous, lobes 5-10 mm long, margins ciliate; corolla campanulate 1.7-3.5 cm long, 1.7-2.8 cm wide, slightly ciliate, pink, purple, violet to blue, lobes not reflexed; style straight; capsule hispidulous 5-7 mm long, 4-7 mm wide, opening by pores at base; seeds 1-1.2 mm long. (N=34, 51) June to September; roadsides, weedy places, woods, abandoned gardens; rare; confined to the mountains in Virginia; native of Eurasia; introduced from N.S. to N.D., south to Va. and Mo.

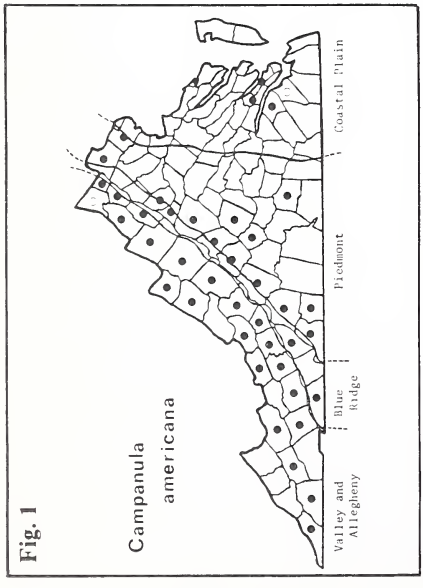
An additional introduced species, Campanula persicifolia L., has been found persisting at one locality in Va. (Madison Co., Mazzeo 2133, NA). This species differs from Campanula rapunculoides in having erect flowers, glabrous hypanthia and calyx lobes, and narrower leaves.

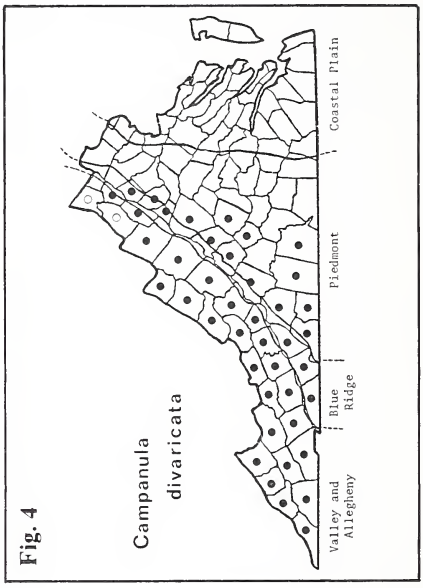
3. Campanula aparinoides Pursh (like Galium aparine, from its adherent foliage), Marsh Bellflower. Perennial from slender rhizomes; stems weak, reclining, more or less 3 angled, usually scabrous on angles, 15-68 cm; leaves linear to lanc-elliptic, 0.5-0.8 mm wide, 0.8-3.7 cm long, crenulate or serrulate to nearly entire, glabrous, acute, scabrous on edges and midvein below, reduced up the stem; inflorescence lax; bracts leafy to linear above; flowers on narrow pedicels 0.8-4.5 cm long; calyx glabrous, lobes 1-2 mm long, lanceolate to triangular, very slightly toothed to entire; corolla campanulate, 4.0-6.5 mm long, 5-10 mm wide, glabrous, light blue to nearly white, lobes not reflexed; style straight, included; capsule glabrous, 1-2 mm long, 1-2.5 mm wide, opening by pores near the base. July-August; wet meadows, marshes, swamps, and boggy thickets; rare; primarily in the mountains of Virginia; N.S. and Que. to Sask., south to N.C., Ky., Mo., and Nebr.

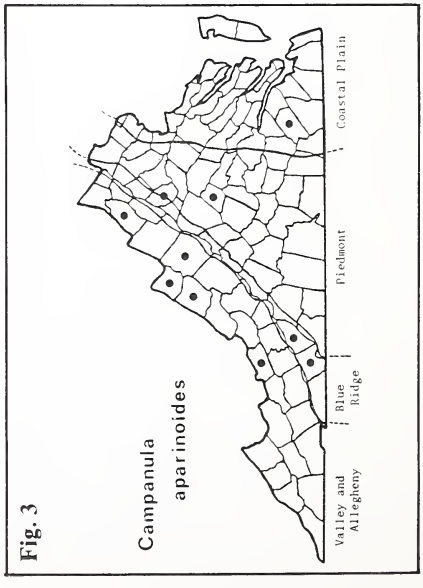
4. Campanula divaricata Michaux (widely divergent), Southern Harebell. Perennial with one to numerous erect stems from a crown; stems very slightly pubescent to glabrous, 21-94 cm, sometimes pigmented below; leaves ovate to linear, 0.1-2.8 cm wide, 0.7-9.0 cm long, distinctly toothed, glabrous to nearly so, acute to acuminate, largest often in middle of stem; inflorescence

profusely branched, with numerous flowers; bracts leafy to linear, glabrous, toothed to entire; pedicels straight to deflexed, glabrous or nearly so; calyx glabrous, lobes 1.0-3.5 mm long, lanceolate to triangular, entire to toothed; corolla campanulate, 5-8 mm long, 6-10 mm wide, glabrous, white to lead blue to bright blue, lobes reflexed; anthers around 2 mm long; style straight, exserted, 8-13 mm; capsule 3-5 mm long, 2-4 mm wide, opening by pores at base; seeds smooth, tan, 0.6-1.1 long, 0.3-0.5 mm wide.









Figs. 1-4

(N=17, 20) June-October; rocky woods, rock walls, talus slopes, dry soil, and shale barrens; common in the mountains of Virginia; chiefly at low elevations in the Appalachian Mountains from Md. and Ky. to Ga. and Ala.

2. Triodanis Raf., Venus' Looking-Glass

Annual herbs with branching fibrous roots; stems erect, strict or much branched below; leaves alternate, sessile except basally, often clasping; inflorescence usually composed of both chasmogamous and cleistogamous flowers; flowers sessile or nearly so, axillary; calyx lobes 3-5, linear to triangular; corolla actinomorphic, rotate, 5-parted, joined below, blue to lavender, to rarely white; stamens 5, distinct; filaments ciliate at base; stigma (2)-3 lobed; ovary inferior; capsule ellipsoid to linear, (2)-3 locular, poricidal, opening laterally. A genus of 8 to 12 species of North and South America and the Mediterranean region. Historically considered to be congeneric with Specularia Fabr.

1. Triodanis perfoliata (L.) Nieuwl. (with leaf meeting around the stem). Annual herb; stems erect, angled, strict or much branched below, 13-74 cm tall, with appressed to spreading pubescence; lower and basal leaves elliptic to ovate, often with short petioles, to 1.9 cm wide and 3.7 cm long, pubescent, crenate to serrate, obtuse to acute; cauline leaves sessile, often clasping; inflorescence occasionally extending nearly to base of plant with both cleistogamous and 1-many chasmogamous flowers; flowers sessile in clusters of 1-4-(10) in the axils of sessile, often clasping bracts; calyx lobes entire or toothed basally, 1-8 mm long, glabrous to slightly pubescent, often ciliate; corolla rotate, blue, purple, to rarely white, 5-17 mm long, 5-21 mm wide, glabrous to slightly pubescent; capsule elliptic to linear, 2-8 mm long, 1.5-3.5 mm wide, poricidal, opening laterally; seeds smooth to slightly roughened, tan to brown, dull to lustrous, 0.5-0.7 mm long. (N=28) Old fields, weedy areas, and disturbed sites. Two integrading varieties:

Upper leaves and bracts strongly clasping; chasmogamous flowers usually numerous; bracts as wide as long or wider; capsules ellipsoid to nearly linear with pore usually at least 1 mm below apex; May-August; abundant; essentially statewide; Maine to B.C., south to tropical America [Specularia perfoliata (L.) DC.]..... var. perfoliata.

Upper leaves and bracts only slightly clasping to not so; chasmogamous flowers usually 1-(2); bracts usually longer than wide; capsule usually linear with pore at apex; May-June; rare; confined to southeastern Piedmont and southern Coastal Plain in Virginia; southern Va. to Ky. and Mo., south to tropical America [Specularia biflora (R. & P.) Fisch. & Mey]..... var. biflora (Ruiz and Pavon) Bradley.

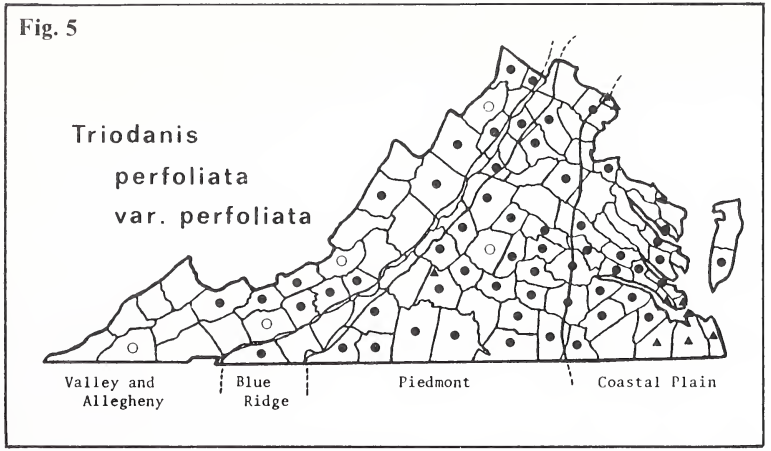


Fig. 5
Triodanis
perfoliata
var. perfoliata
Valley and Allegheny
Blue Ridge
Piedmont
Coastal Plain

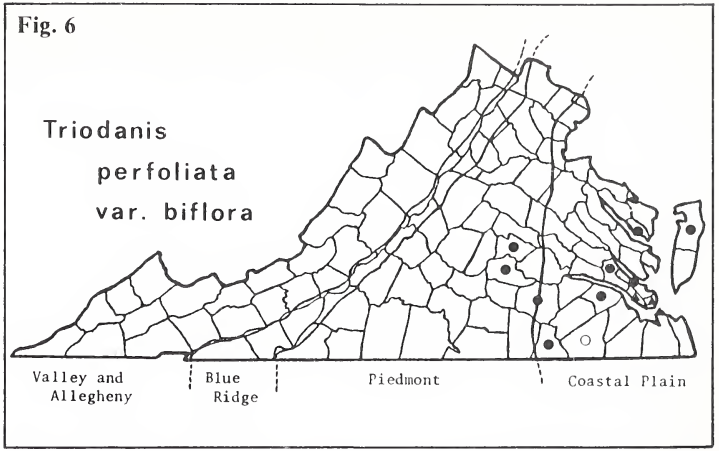


Fig. 6
Triodanis
perfoliata
var. biflora
Valley and Allegheny
Blue Ridge
Piedmont
Coastal Plain

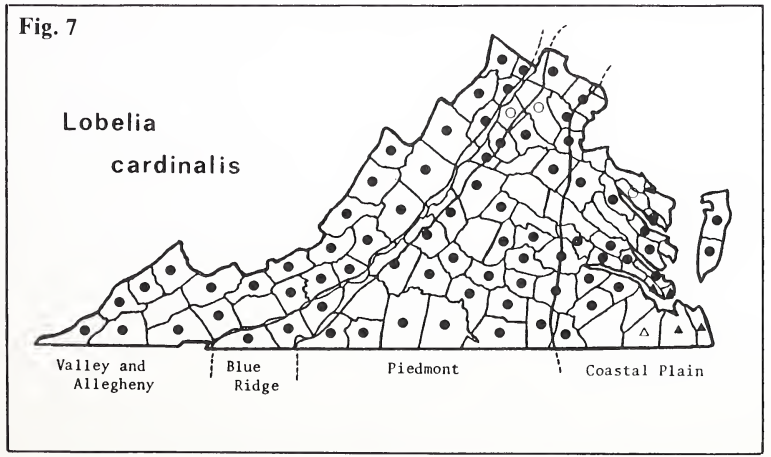


Fig. 7
Lobelia
cardinalis
Valley and Allegheny
Blue Ridge
Piedmont
Coastal Plain

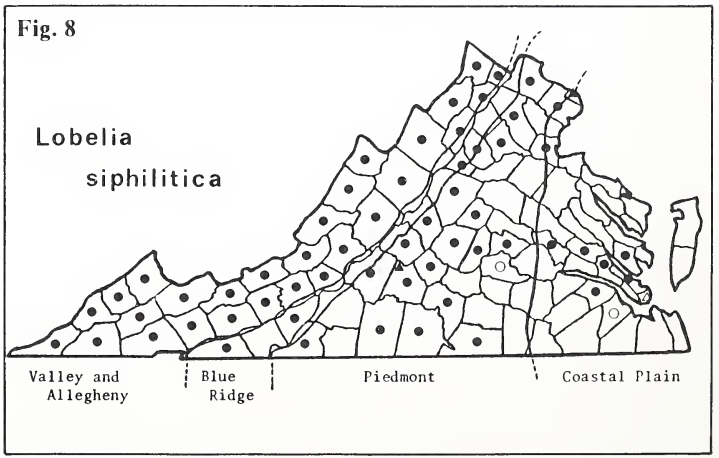


Fig. 8
Lobelia
siphilitica
Valley and Allegheny
Blue Ridge
Piedmont
Coastal Plain

Figs. 5-8

3. Lobelia L., Lobelia

Perennial or annual herbs with milky sap; stems erect; leaves alternate, simple, exstipulate, usually with callose-tipped teeth; inflorescence racemose to paniculate, terminal, bracteate, or rarely axillary; flowers inverted by twisting of the pedicel, perfect, 5-merous, zygomorphic, epigynous or partly so; corolla sympetalous, 2-lipped, tube split nearly to base between the upper two lobes; stamens 5, usually free from the corolla; filaments free at base but distally united; anthers united into a tube; stigma 2-lobed; hypanthium appendicular;[2] capsule 2-locular, opening apically; seeds many, foveolate-reticulate. (Dedicated to Matthias de l'Obel, 1538-1616, Flemish herbalist.) A cosmopolitan genus of between 200 and 300 species, most strongly represented in the Southern Hemisphere.

[2]The morphology of the hypanthium has been discussed for a related member of the Lobelioideae, Downingia bacigalupii, by Kaplan (1967).

Key to Lobelia L.

1. Flowers (including hypanthium) more than 15 mm long; corolla fenestrate (i.e. with a slit-like opening on each side near the base).....2
   2. Corolla red to crimson; flowers (including hypanthium) 3.1-4.6 cm long.....L. cardinalis
   2. Corolla blue, violet, or white; flowers (including hypanthium) 1.3-3.3 cm long.....3
      3. Calyx lobes with basal auricles 1.5-4 mm long; pedicels with bracteoles at or above the middle..... L. siphilitica
      3. Calyx lobes without basal auricles or auricles 1 mm or less long; pedicels bracteolate near the base.....4
         4. Stems with short, dense pubescence throughout..... L. puberula
         4. Stems glabrous or essentially so.....5
            5. Calyx lobes with callous or gland-tipped teeth; leaves broadly lanceolate to ovate-elliptic..... L. georgiana
            5. Calyx lobes entire or nearly so; leaves linear to lance-linear..... L. elongata

1. Flowers (including hypanthium) less than 13 mm long; corolla not fenestrate.....8
   8. Central stem leaves linear or narrowly lanceolate, the largest usually less than 5 mm wide; lower tip of corolla glabrous at base..... L. nuttallii
   8. Central stem leaves broader, the largest usually more than 8 mm wide; lower lip of corolla pubescent at base.....9
      9. Hypanthium at maturity greatly inflated; stems usually much branched..... L. inflata
      9. Hypanthium at maturity not inflated; stems simple or with a few branches..... L. spicata

1. Lobelia cardinalis L. (pre-Linnaean generic name for Lobelia, meaning of the Cardinal; from color and shape of the corolla, like a miter), Cardinal Flower. Perennial fibrous rooted herb from basal offshoots; non-rhizomatous; stems erect, terete to angled, coarse, glabrous to hirsutulous to pubescent, 0.4-2.0 m tall, usually unbranched, occasionally reddish at base; leaves ovate-elliptic to nearly linear, rarely obovate, 0.4-8.1 cm wide, 2.4-20.1 cm long, glabrous to pubescent, crenulate to serrate to dentate, obtuse to acuminate, reduced and narrowed up the stem; lower leaves occasionally petiolate; inflorescence racemose, 2.5-53.0 cm long; bracts leafy to linear above, glabrous to pubescent; glandular crenulate to serrate, rarely nearly entire; pedicels 2-20 mm long, with 1-2 basal bracteoles; flowers including hypanthium 3.1-4.3 cm long; calyx lobes 8-20 mm long, 1-3 mm wide, linear to subulate, glabrous to slightly pubescent, ciliate or not so, rarely with slight basal auricles; corolla red to scarlet, rarely pink in forma rosea St. John or white in forma alba (Eat.) St. John, glabrous to slightly pubescent, 1.2-2.4 cm wide, tube fenestrate, 1.5-1.9 cm long, lower lobes 1.4-21. cm long; filament tube 2.2-2.3 cm long; hypanthium hemispheric at maturity, 0.4-1.2 cm wide, 0.3-1.2 cm long; capsule approximately half inferior; seeds 0.8-1.2 mm long. (N=7) July-October; low woods, marshes, swamps, stream margins, and rarely in shallow water; often locally abundant; common statewide in Virginia; New Brunswick to Minn., south to Tex. and Fla.

2. Lobelia siphilitica L. (from formerly reputed curative properties), Great Lobelia, Blue Cardinal Flower. Perennial fibrous rooted herb arising by basal offshoots; non-rhizomatous; stems erect, slightly angled, nearly glabrous to pubescent, most commonly only slightly so, to 110 cm tall, strict to occasionally branched above; leaves thin, lance-elliptic to ovate-elliptic, 0.8-5.8 cm wide, 2.3-19 cm long, nearly glabrous to pubescent, nearly entire to crenulate to serrate, obtuse to acute; lower leaves often obovate-elliptic to rarely spatulate; inflorescence racemose, not secund or rarely slightly so, to 75 cm long; bracts leafy to linear above; pedicels 2.5-9 mm long, usually long pubescent with two bracteoles just below the hypanthium or occasionally to middle of pedicel; flowers including hypanthium 2.1-3.2 cm long; calyx lobes 9-17 mm long, 2-5 mm wide, lanceolate to lance-ovate, minutely toothed and typically densely ciliate, with large (to 4 mm long) basal auricles, often with bluish-purple pigmentation; corolla blue, usually with white lines on ventral portion of tube to rarely white in forma albiflora Britt., pubescent at tips of lobes and on veins to rarely nearly glabrous, 1.0-2.1 cm wide, tube fenestrate, lower lobes to 1.1 cm long; filament tube 12-16 mm long; hypanthium hemispherical at maturity, 6-11 (17) mm wide, 5-9 mm long; seeds light brown to tan, 0.5-1 mm long. (N=7) August-October; low woods, stream margins, ditches, swamps, and marshes; common in Virginia mainly in the Mountains and Piedmont, local on the Coastal Plain; Maine through southern Ontarion to Minn., south to Tenn. to Ala.

3. Lobelia puberula Michaux. (puberulent), Downy Lobelia, Purple Dewdrops. Perennial fibrous rooted herb from basal offshoots; non-rhizomatous; stems erect, angled to nearly terete, densly puberulent to rarely only slightly so, 21-160 mm tall, usually strict to occasionally branched, occasionally with purple pigmentation below; leaves ovate to elliptic to lance-elliptic, 0.2-4.3 cm wide, 0.9-4.3 cm wide, 0.9-13 cm long, puberulent, nearly entire to serrate-dentate, obtuse to acute, reduced up the stem and merging with the bracts; lowest leaves often petiolate, spatulate, obtuse and occasionally pigmented; inflorescence racemose, usually secund, to 63 cm long; bracts leafy to nearly

linear above; pedicels 1-4 mm long, usually densely puberulent, with bracteoles typically near the base to very rarely near the middle; flowers including hypanthium 14-23 mm long; calyx lobes 5-14 mm long, to 3.5 mm wide, linear to subulate, pubescent, usually ciliate, with small (to 1 mm) basal auricles, occasionally with bluish-purple pigmentation; corolla blue to purple with white throat or rarely with white markings on lower lip, puberulent, tube fenestrate, 71-20 mm long; filament tube 6-9 mm long; hypanthium hemispheric, 6-8 mm wide, 4-6 mm long; capsule approximately half inferior; seeds tan to light brown, 0.5-1.0 mm long. (N=7) (May)-late July-October; forest margins, moist areas, banks, woods, and roadsides; occasional; in Virginia primarily east of the Blue Ridge, scattered to thw west; N.J. to Fla., west to Ill., Okla., and Tex.

4. Lobelia georgiana McVaugh. (of Georgia). Perennial fibrous rooted herb from basal offshoots; non-rhizomatous; stems rather weak to strongly erect, slightly angled, glabrous to slightly pubescent, 72-99 cm tall, usually unbranched, occasionally darkened at base; leaves thick to thin, broadly lanceolate to ovate-elliptic, 0.2-3.2 cm wide, 1.1-9.0 cm long, glabrous to slightly short pubescent, nearly entire to crenate to serrate, obtuse to acute, reduced up the stem; lowest leaves occasionally petiolate, spatulate; inflorescence racemose, not usually secund, 12-40 cm long; pedicels 2-5 mm, erect or ascending in fruit, usually glabrous to rarely slightly roughened, with basal bracteoles; flowers including hypanthium 18-25 mm long; calyx lobes linear to lance-linear, with (1)-2-3-(4) gland-tipped teeth per side; corolla pale to dark blue, glabrous, (9)-14-20 mm wide, tube fenestrate; filament tube 7-8 mm long; hypanthium hemispheric to subglobose at maturity, 4.5-7 mm wide, 3.5-7 mm long; capsule approximately half to three-fourths inferior; seeds 0.7-0.8 mm long. (N=7) August to October-(Nov.); damp woods, swales, swamps, and marshes; rare; primarily in the Piedmont and inner Coastal Plain in Virginia; Va. to Fla., west to Tenn. (L. amoena var. glandulifera Gray; L. glandulifera (Gray) Small, not Ktze.).

5. Lobelia elongata Small. (elongate). Perennial fibrous rooted herb from basal offshoots; non-rhizomatous; stems erect, slightly angled, glabrous, to 112 cm tall, usually unbranched, occasionally reddish at base; leaves linear to narrowly lanceolate, 0.8-1.0 cm wide, 8.2-9.0 cm long, glabrous or nearly so, crenate to serrate, obtuse to acuminate, reduced up the stem; racemose inflorescence usually strongly secund, 15.5 cm long; bracts resembling reduced leaves; pedicels arched or curving to one side in fruit, roughened to rarely nearly smooth, with a pair of basal bracteoles; flowers including hypanthium 23-25 mm long; calyx lobes 7-15 mm long, glabrous, entire to rarely with a single tooth; corolla deep blue to violet, glabrous, tube fenestrate; filament tube 10-12 mm long; hypanthium subglobose at maturity, 6-7 mm wide, 6-7 mm long; capsule typically inferior; seeds approximately 0.9 mm long. (N=14) September to October; fresh to brackish swales; very rare, at present possibly extinct in Virginia; Virginia collections known only from the cities of Virginia Beach and Chesapeake; southern Delaware to Georgia.

An additional species, Lobelia glandulosa Walter, closely resembling L. elongata but with callous-tipped calyx teeth has in the past been attributed to Va. on the basis of two specimens. One of these (Norfolk Co., Kearney 2378, US), however has since been determined to be a specimen of L. elongata. The only other known material is a collection by Baily (s.m., NY) in 1841 labelled only as coming from Virginia. Identification is uncertain because the material is sparse and seems to be a mixed collection. Since this species has apparently not been found in Va. since 1841, it

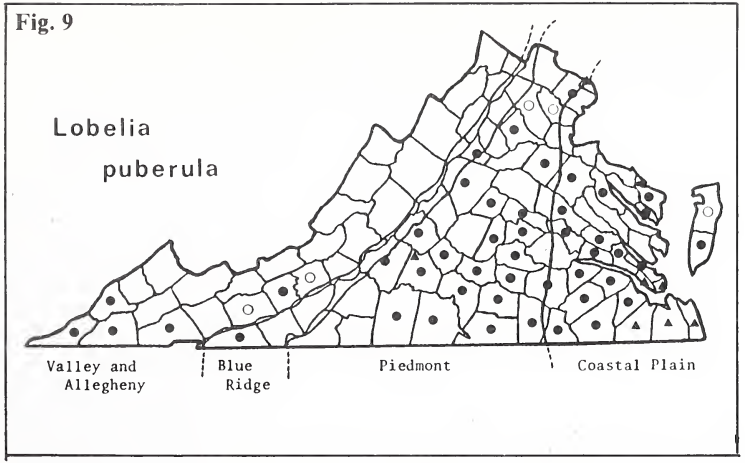


Fig. 9
Lobelia
puberula
Valley and Allegheny
Blue Ridge
Piedmont
Coastal Plain

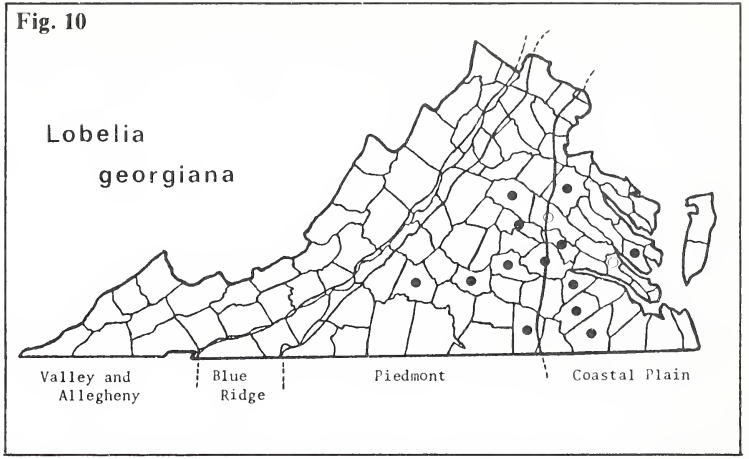


Fig. 10
Lobelia
georgiana
Valley and Allegheny
Blue Ridge
Piedmont
Coastal Plain

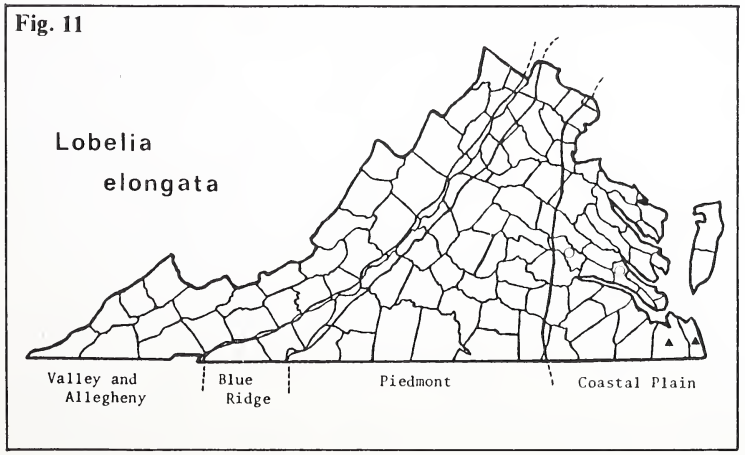


Fig. 11
Lobelia
elongata
Valley and Allegheny
Blue Ridge
Piedmont
Coastal Plain

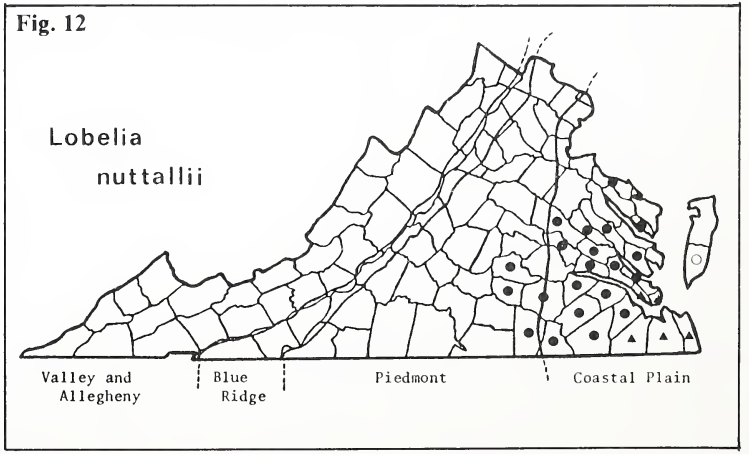


Fig. 12
Lobelia
nuttallii
Valley and Allegheny
Blue Ridge
Piedmont
Coastal Plain

Figs. 9-12

is probable that L. glandulosa is no longer a member of the state flora.

6. Lobelia nuttallii R. & S. (for its discoverer, Thomas Nuttall, 1786-1859). Fibrous rooted herb; stems slender, nearly terete to slightly angled, glabrous or nearly so, to 90.5 cm tall, often freely branched, often reddish below; basal leaves ovate to oblanceolate, occasionally petioled, 0.4-1.2 cm wide, 0.6-4.2 cm long, glabrous to slightly pubescent, nearly entire to crenulate, typically obtuse, often with reddish-purple pigmentation; stem leaves often reduced, oblanceolate to linear, to 7 mm wide, 0.4-3.7 cm long, acute or obtuse below, inflorescence racemose, often with smaller secondary racemes, to 70.5 cm long; bracts reduced upward, linear; pedicels 2-9 mm long, glabrous or with a few short stout hairs, with basal bracteoles, often with pigmentation; flowers including hypanthium 7.5-10.5 mm long; calyx lobes 1-4 mm long, linear to lanceolate, often pigmented; corolla light blue to blue and white, usually with two yellow to green dots at base of lower lip, 3-7 mm wide, tube not fenestrate, lower lip glabrous at base; filament tube 4-7 mm long; hypanthium short-hemispherical, 2-3 mm wide, 2.5-3.5 mm long; capsule approximately half inferior; seeds 0.3-0.6 mm long. (N=7,14) June to September-(Oct.); low woods, moist fields, marshes, bogs, dry sandy areas; occasional; in Virginia confined to the Coastal Plain and eastern Piedmont; Fla. to Long Island, west to Ky. and Tenn.

7. Lobelia inflata L. (inflated, referring to the hypanthium), Indian Tobacco, Wild Tobacco. Annual or biennial herb from a branched root; stems erect, slightly angled, with dense spreading pubescence, to 94.5 cm tall, usually much branched, often reddish below; leaves lanceolate to ovate, 0.4-4.3 cm wide, 1.5-10.7 cm long, pubescent, crenulate to serrate, obtuse to acute, largest often located at the lower middle part of the stem; lower leaves obovate-elliptic to spatulate; inflorescence terminating leafy branches; bracts leafy to linear above; pedicels 1-10 mm long, puberulent to rarely nearly glabrous, with basal bracteoles; flowers including hypanthium 0.5-1.0 cm long; calyx lobes 2-7 mm long, linear, often ciliate; corolla nearly white to pale lavender or blue, often light blue limbs with white to light lavender throat, green dots occasionally seen at base of lower lip, 2-7 mm wide, tube not fenestrate, lower lip usually pubescent at base; filament tube 2-4.5 mm long; hypanthium elliptic to nearly globose, greatly inflated and covering the capsule at maturity, 3-7.5 mm wide, 3-11 mm long; capsule inferior; seeds tan to brown, 9.6-1.0 mm long. (N=7) July-October-(Nov.); open woods, disturbed sites, roadsides, and weedy areas; common statewide in Virginia but less common on the Coastal Plain; Canada to Ga. and Missl, west to Kansas.

8. Lobelia spicata Lam. (spicate), Pale-Spike Lobelia, Highbelia. Perennial fibrous rooted herb arising by basal offshoots; non-rhizomatous; stems erect, slightly angled, with densely appressed or rarely spreading pubescence to nearly glabrous, to 95 cm tall, usually strict or only slightly branched, occasionally red pigmented at base; basal leaves present or absent, obovate, obovate-elliptic, to oblong, often tapering to a petiole, 0.7-4.1 cm wide, 1.6-12 cm long, pubescent, usually crenulate to nearly entire, typically obtuse, often with red to purple pigmentation; cauline leaves prominent to reduced or nearly lacking, obovate-elliptic to lance-linear above, 0.1-3.4 cm wide, 0.9-10 cm long, nearly entire to crenulate to denticulate, acute or obtuse below; inflorescence to 53 cm long;

bracts distinct, lanceolate to linear; pedicels 2-6 mm long, nearly glabrous to slightly puberulent, with basal bracteoles; flowers including hypanthium 6-12 mm long; calyx lobes 1.5-6 mm long, linear to broadly lanceolate, glabrous, with basal auricles to 1 mm, occasionally with reddish purple pigmentation; corolla leaden white to lavender-blue, often with light blue limbs and a white throat, 0.4-1.2 mm wide, tube not fenestrate, limbs to 5 mm long, lower lip pubescent to rarely glabrous at base; filament tube 3-4.5 mm long; hypanthium at maturity short hemispheric to subglobose, 2-5 mm wide, 3-5 mm long; capsule one-half to three-fourths inferior; seeds light brown, 0.5-0.8 mm long.

(N=7) May to August; rich woods, wooded slopes, fields and roadsides; occasional; in Virginia primarily in the Mountains and Piedmont, rare in the Coastal Plain; New Brunswick and Me. to Minn., south to Ga. and La.

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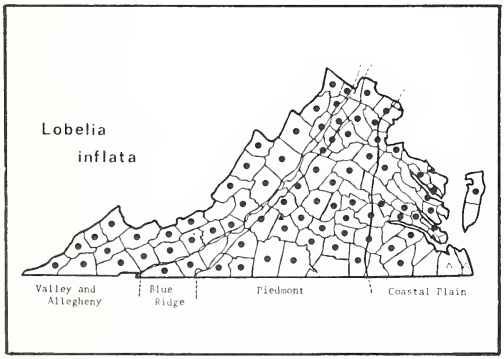

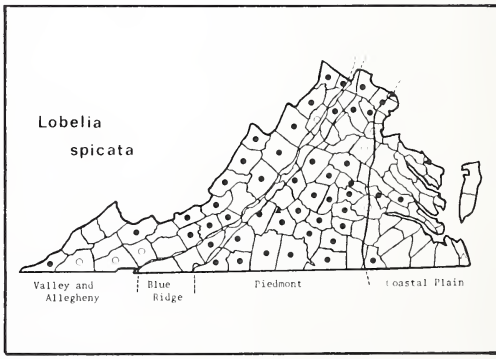

Figs. 13-14

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